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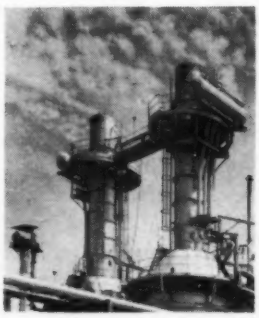

A view of the 200-tpd "HyL" plant at Monterrey, Mexico, for the production of sponge iron from ore and reformed natural gas. The plant is the forerunner of a 500-tpd unit under construction by the M. W. Kellogg Co. of New York (*see page* 168)

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Résumés

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LE PROCÉDÉ DU FER SPONGIEUX HyL

par R. Lawrence, Jr.

L'auteur donne l'historique et des détails d'un procédé permettant de fabriquer du fer par réduction du minerai de fer au moyen d'un mélange d'hydrogène et d'oxyde de carbone dérivé de gaz naturel. Le fer spongieux donne, en passant par le four électrique, un acier de très haute qualité industrielle.

B.C.E., 5, 3, 172. U.D.C. No. 66.061.5.

CALCULS GRAPHIQUES SIMPLIFIÉS DANS LES EXTRACTIONS LIQUIDE/LIQUIDE

par R. Blumberg

L'application de la méthode graphique de McCabe-Thiele, qui permet d'estimer le nombre de phases de contraction dans l'extraction d'un liquide d'un autre liquide, était limitée, dans le passé, aux extractions intéressant deux solvants mutuellement immiscibles, lorsqu'il n'y avait aucun changement de volume dans l'une ou l'autre phase et lorsque le soluté n'entrait qu'avec l'alimentation. En sélectionnant judicieusement les éléments, on peut maintenant adapter cette méthode aux deux cas que nous venons de citer. Le procédé est illustré par trois exemples pratiques.

B.C.E., 5, 3, 174. U.D.C. No. 66.074.1:661.183.

APPLICATION DU SYSTÈME POLYBLOC À LA CONSTRUCTION DE COLONNES D'ABSORPTION

par A. J. Hilliard

Pour l'absorption des gaz dont la température de dissolution dans l'eau est élevée, on a intérêt, lorsque les solutions obtenues sont corrosives, à utiliser une colonne d'absorption à graphite d'un dessin nouveau qui offre certains avantages sur la colonne à remplissage conventionnel. La chaleur est facilement éliminée et la pellicule de liquide conservée lorsqu'elle passe à travers les passages de la colonne d'absorption. En même temps, les pertes de pression des gaz sont minima.

B.C.E., 5, 3, 179. U.D.C. No. 66.074.1.

MOUVEMENTS CONTRAIRES DE GAZ ET DE LIQUIDE À TRAVERS LES LITS D'ANNEAUX DE RASCHIG REMPLIS AU HASARD

par F. R. Whitt

L'article montre que la distribution de l'écoulement gazeux et liquide sur les surfaces des anneaux de remplissage est influencée par la taille des anneaux. Lorsqu'ils sont petits, 12–15 mm, le liquide se déplace uniformément sur les surfaces intérieures et extérieures des anneaux, mais le gaz s'écoule principalement sur les surfaces extérieures. Lorsque les anneaux de remplissage sont plus gros, 25 mm et plus, l'écoulement du gaz est distribué uniformément sur les deux surfaces tandis que le liquide s'écoule surtout sur les surfaces intérieures.

B.C.E., 5, 3, 183. U.D.C. No. 66.013.5.003.

DESSIN, DÉVELOPPEMENT ET RECHERCHE DANS LES ENTREPRISES DE CONSTRUCTION D'INSTALLATIONS CHIMIQUES

par M. Davidmann

A moins que les fonctions des divers services intéressés dans la construction d'une usine ou installation de produits chimiques soient clairement définies, il est évident que certains problèmes finiront par se faire jour. L'auteur analyse les fonctions des services du dessin, des développements et des recherches et il démontre qu'un service dont les fonctions sont mal définies peut être amené, si des mesures appropriées n'ont pas été adoptées, à essayer d'acquérir le travail d'autres services.

B.C.E., 5, 3, 191. U.D.C. No. 66.045.5:624.97.

TENDANCES NOUVELLES DANS LE DESSIN DES TOURS DE REFROIDISSEMENT

par D. Tow

L'auteur passe en revue le développement des procédés de dessin pour la construction de tours de refroidissement et esquisse une méthode communément appliquée. Il examine ensuite le remplissage, l'élément le plus important d'une tour de refroidissement. Il conclut que le remplissage type grille en plastique est le plus satisfaisant car il fournit une bonne masse et un excellent transfert de chaleur, il est économique et durable. Ce genre de remplissage a des vastes possibilités d'application, par exemple dans les filtres lents, l'absorption chimique et l'élimination de la poussière et de gouttelettes d'eau dans l'atmosphère.

Kurzreferate

B.C.E., 5, 3, 168. U.D.C. No. 669.181.4.

DAS HYL'SCHE EISENSCHWAMM-VERFAHREN

von R. Lawrence, Jr.

Die Geschichte und Einzelheiten eines Verfahrens der Eisenherstellung durch Reduktion von Eisenerz mittels eines aus Naturgas hergestellten Wasserstoff-Kohlenoxyd-Gemisches. Der Eisenschwamm ergibt bei Behandlung im Elektroofen einen ausgezeichneten Fabrikationsstahl.

B.C.E., 5, 3, 172. U.D.C. No. 66.061.5.

VEREINFACHTE GRAPHISCHE BERECHNUNG VON FLÜSSIGKEITSEXTRAKTIONEN AUS FLÜSSIGKEITEN

von R. Blumberg

Die graphische Methode von McCabe-Thiele zur Bestimmung der Kontraktionsstufen bei Flüssigkeitsextraktionen aus Flüssigkeiten beschränkte sich bisher auf Extraktionen unvermischbarer Lösungsmittel, bei welchen in keiner Phase eine Volumensänderung vorkommt, und wobei der aufgelöste Stoff nur durch den Einlass einläuft. Durch richtige Wahl der Komponenten lässt sich die Methode auch auf die beiden letzteren Fälle anwenden. Der Vorgang wird an Hand dreier Beispiele erläutert.

B.C.E., 5, 3, 174. U.D.C. No. 66.074.1:661.183.

DAS POLYBLOCKSYSTEM IN DER KONSTRUKTION VON ABSORPTIONS-APPARATEN

von A. J. Hilliard

Für die Absorption von Gasen mit hoher Wasserlösungswärme und bei welchen die Lösungen korrosive Eigenschaften besitzen, eignet sich besonders eine neue Konstruktion eines Graft-Absorptionsapparats, welcher den konventionellen Säulen gegenüber Vorteile bietet. Die Wärme lässt sich leicht ableiten und der Flüssigkeitsfilm bleibt beim Durchlaufen durch die Leitungen des Absorptionsapparats bestehen. Druckverluste der Gase werden hierdurch ebenfalls auf ein Mindestmass beschränkt.

B.C.E., 5, 3, 179. U.D.C. No. 66.074.1.

GEGENFLUSS-GAS- UND FLÜSSIGKEITS-FLUSS DURCH LAGEN VON REGELLOS GEPACKTEN RASCHIG-RINGEN

von F. R. Whitt

Die Verteilung eines Gas oder Flüssigkeitsflusses über die Oberfläche von Ringpackungen hängt von der Packungsgrösse ab. Bei kleinen, 12–15 mm Packungen verteilt sich der Fluss der Flüssigkeit gleichmässig über die inneren und äusseren Flächen der Ringe, während er bei Gasen grösstenteils die äusseren Oberflächen umfliesst. Bei grösseren Packungen von 25 mm und darüber umfliesst der Gasfluss wahrscheinlich gleichmässig beide Oberflächen, der Flüssigkeitsfluss jedoch grösstenteils die innere.

B.C.E., 5, 3, 183. U.D.C. No. 66.013.5.003.

KONSTRUKTIONEN, ENTWICKLUNG UND FORSCHUNG IM CHEMIE-ANLAGENBAU

von M. Davidmann

Wenn die Zusammenhänge nicht genau definiert sind, kommt es leicht zu Problemen zwischen den verschiedenen, an der Planung von chemischen Anlagen interessierten Abteilungen. Der Verfasser analysiert die Funktion der Konstruktions-, Entwicklungs- und Forschungsabteilung und zeigt, dass, in Abwesenheit angemessener Massnahmen, eine Abteilung ohne genau definierten Funktionsaufgaben die Arbeit anderer Abteilungen übernehmen kann.

B.C.E., 5, 3, 191. U.D.C. No. 66.045.5:624.97.

NEUE KÜHLTURMKONSTRUKTIONEN

von D. Tow

Der Autor gibt eine Übersicht über die Entwicklung im Kühlturmbau und berichtet über eine gegenwärtig benützte Methode. Im Weiteren wird der wichtigste Teil des Kühlturmes, die Packung, besprochen. Es scheint, dass eine plastische Gitterpackung den Anforderungen guter Wärmeableitung, Wirtschaftlichkeit und Dauerhaftigkeit am besten entspricht. Diese Art von Packung hat weitgehende Möglichkeiten in Sickerfiltern, chemischen Absorptionsapparaten, und in der Staub und Nebelbeseitigung.

Резюме

B.C.E., 5, 3, 168. U.D.C. No. 669.181.4.

ПРОИЗВОДСТВО ГУБЧАТОГО ЖЕЛЕЗА ПРОЦЕССОМ ФИРМЫ «ХИЛ»

Р. Лоуренс, мл.

Развитие и подробности процесса производства железа путем выделения металла из руды, при помощи водорода и окиси углерода, извлекаемой из естественного газа. Губчатое железо обработанное в электрической печи дает высококачественную готовую сталь.

B.C.E., 5, 3, 172. U.D.C. No. 66.061.5.

УПРОЩЕННЫЕ ГРАФИЧЕСКИЕ РАСЧЕТЫ ПРИ ИЗВЛЕКАЮЩЕМ ВЗАИМОДЕЙСТВИИ ЖИДКОСТЬ-ЖИДКОСТЬ

Р. Блумберг.

Графический метод «Мак-Каб-Тиль» для определения количества стадий сокращения при извлечении жидкости из жидкости, в прошлом ограничивался извлечением включавшим два общих, несмешивающихся растворителя — при котором ни в одной стадии не происходит изменений в об'еме и при котором растворенное вещество входит лишь с подачей. При рациональном отборе компонентов, этот метод можно использовать и в двух последних случаях. Применяемый процесс иллюстрируется тремя испробованными примерами.

B.C.E., 5, 3, 174. U.D.C. No. 66.074.1:661.183.

ПРИМЕНЕНИЕ МНОГО-БЛОКОВОЙ СИСТЕМЫ В КОНСТРУКЦИИ АБСОРБЕРОВ

А. Ж. Хиллиард.

Для абсорбации газов, выделяющих много тепла при растворении в воде, а также в тех случаях где получаются коррозийные растворы — графитный абсорбер нового типа обладает преимуществами над насадочной колонной обычного типа. Тепло легко удаляется и тонкий, жидкий слой сохраняется во время его прохода через каналы абсорбера. Одновременно потеря газового давления сокращается до минимума

B.C.E., 5, 3, 179. U.D.C. No. 66.074.1.

ПРОТЕКАНИЕ ГАЗА И ЖИДКОСТИ (ПРИ ВСТРЕЧНОМ НАПРАВЛЕНИЙ) СКВОЗЬ НАСАДКУ ИЗ НЕ ПОДОБРАННЫХ КОЛЕЦ РАШИГА

Ф. Р. Уитт.

Распределение газа и жидкости по поверхности кольцевой насадки зависит от размера насадочного матерьяла. Так в мелкой насадкой — 12-15 мм — жидкость равномерно растекается по внешним и внутренним поверхностям колец, но газ течет главным образом по внешним поверхностям. При более крупной насадке — 25 мм и выше — газ, вероятно, распределяется равномерно по обеим поверхностям, в то время как жидкость течет главным образом по внутренним поверхностям.

B.C.E., 5, 3, 183. U.D.C. No. 66.013.5.003.

КОНСТРУКЦИЯ, РАЗВИТИЕ И ИССЛЕДОВАТЕЛЬСКАЯ РАБОТА ПРИ РАЗРАБОТКЕ ПРОЕКТОВ ХИМИЧЕСКИХ УСТАНОВОК

М. Давидманн.

Между различными отделами работающими над проектами химических установок безусловно возникают трудности если не будут точно определены их функции и отношения друг с другом. Автор статьи анализирует работу отделов занятых конструкцией, развитием и исследованием, доказывая, что если не будут приняты надлежащие меры — отдел, функции которого точно не определены, может пытаться заполучить работу других отделов.

B.C.E., 5, 3, 191. U.D.C. No. 66.045.5:624.97.

НОВШЕСТВА В КОНСТРУКЦИИ БАШЕННЫХ ХОЛОДИЛЬНИКОВ

Д. Тоу.

Статья содержит обзор развития методов конструкции башенных холодильников и приводит метод, применяющийся в данное время. Автор статьи пишет затем о прокладке — самой важной части башенного холодильника и приходит к заключению, что прокладка типа пластической решетки лучше других обеспечивает хорошую передачу массы вещества и тепла, а также рентабельна и прочна. Такой тип прокладки имеет потенциальные возможности применения в таких различных областях, как например в капельных фильтрах, в химической абсорбации и в устранении пыли и влаги.

DIGEST OF INDUSTRIAL AND TECHNICAL DEVELOPMENTS

Petroleum Chemicals Go On Booming

THE latest OEEC report *states that chemical production in West Europe rose in 1958 at three times the rate for industrial production as a whole. The rise is faster than that in the United States. Separate " sector " studies showed the most spectacular expansion to have been in petroleum chemicals where output in terms of carbon content increased by 29% over 1957 after having risen by 34% in the previous year. These international reports take some time to prepare and it is necessary to recall that in 1958 the earlier expansion in general industrial activity had slowed considerably and expansion resumed only in the last quarter of that year.

In the petroleum chemical industry of OEEC countries total investment increased by 41% in 1958. However, instead of the slowing down which might have been expected after the rapid development of the preceding years a record investment was expected to be made in the European petroleum chemical industry during the following two years. Thus the size of the industry in 1961 was expected to be more than double that of 1958, when investment amounted to $775 million. Products where output would be appreciably expanded include synthetic rubber (nitrile as well as butyl and S.B. type), plastics materials (mainly polyethylene and polypropylene), ethylene oxide derivatives and solvents.

A general survey of French achievements and plans in this field appears in *Industries et Techniques* for January 1960—incidentally with the price marked in New Francs. More heavily centred on British developments is the article by Professor Frank Morton in the *FBI Review* of the same date. Future developments he points out obviously depend on complete integration of units using products of thermal cracking of the light petroleum distillates now almost exclusively used as charge stock for olefin manufacture.

* The Chemical Industry in Europe, 1958-59 OEEC 15/-. Obtainable at H.M.S.O.

Fluid Bed Fluorination of Uranium Tetrafluoride*

AS part of the development of an alternative route for producing uranium hexafluoride, C. J. VOGEL and W. J. MECHAM at the Argonne National Laboratory have investigated the use of the fluid bed for conversion of the tetrafluoride. Fluorine and nitrogen were used as fluidising gases. In most cases, fluorine formed 25% by volume of the gas mixture. A continuously-fed 2½ in. diameter reactor was employed and four types of uranium tetrafluoride fluorinated. They were refined green salt, and crude uranium tetrafluorides derived from South African (Rand) acid-leached, Anaconda acid-leached, and Anaconda carbonate-leached ore concentrates. Using refined salt the efficiency of utilisation of the fluorine increased with temperature over the range studied, 300° to 450°C. It was over 85% at 400°C. Production rates exceeding 100 lb. uranium hexafluoride per hr, cu. ft of bed, were easily attained.

Despite the fact that diluting the pure salt bed with a solid inert to fluorine—calcium fluoride—reduced the fluorine efficiency, trials on crude uranium tetrafluoride made from South African (Rand) ore concentrate showed reasonable fluorine efficiencies and production rates at 400° and 450°C. One run with Anaconda acid-leached uranium tetrafluoride gave production rates comparable with those of the Rand acid-leached material. Anaconda carbonate-leached uranium tetrafluoride in one run showed a substantially poorer production rate. It was more difficult to process because of a tendency to sinter.

* Report ANL-6054 (TID-4500 15th Ed.). Available from the Office of Technical Services, Department of Commerce, Washington 25, D.C. 75 cents.

Bird's Eye View of Instrumentation

THOUGH the specialist instrumentation engineer is not likely to learn much from it, a new book on process instrumentation* should help other engineers to gain an overall view. Published by the Electrical Development Association, it opens with a general review of automatic control, sensing, instruments and actuators. Later sections on industrial applications include examples in chemical analysis or the control of such properties as flow, level and temperature. Finally, to round off the surveys of other applications are chapters on design and servicing, and one which includes reference to the first closed loop electronic process control system for extracting sugar from beet.

The object of the publication is modestly stated. In the preface the authors disclaim any intention to add to the specialist matter on electronics, measurement and instrumentation; they merely wish to outline in simple form the means by which the variables occurring in manufacturing can be sensed, measured and controlled with the ultimate object of achieving a more completely and perfectly integrated process. It is understandable that pneumatic instruments should receive only brief mention in a book sponsored from this source. The emphasis on electrical methods also results in such oddities as the restriction of flow meters to only one item under that heading—the inductive type—while the Venturi tube is shown as part of a discussion of the true meaning to be attached to the term "meter."

* "Process Integration and Instrumentation" 1959, 8s. 6d. (9s. post free), pp. xx + 203, 141 illustrations.

New Work on Extracting Wax from Peat

DURING the last war investigations were carried out at the Fuel Research Station, Greenwich, on the extraction, properties and constitution of peat wax. The aim was to find a substitute for the previously imported montan wax of German origin. Source materials investigated were lignite from Bovey Tracey (Devon) and peats. In the last paper on the subject from the Station, MR. G. C. ACKROYD concluded that the findings on the constitution of peat wax were not encouraging from the point of view of developing a substitute for montan or vegetable waxes. However, the material was shown to be a source of high-molecular-weight organic compounds containing three or even more functional groups such as carboxylic acid, ester and hydroxyl per molecule.

With molecules of this type it was thought possible to produce plastics with interesting properties and MR. ACKROYD suggested that the future development of peat wax might lie in this direction. (International Peat Symposium, Dublin, July 1954, Section E.1.) When a satisfactory substitute was found elsewhere for imported montan wax and the justification for British work on the subject was considered at an end, work ceased at the Fuel Research Station.

We were reminded of this history on learning that the torch of this investigation has now been picked up by the laboratory of the Northern Ireland Department of Industrial and Forensic Science. As its title indicates, the laboratory provides a wide range of scientific and technical services to official and industrial bodies. In the field of chemical engineering, the Director, DR. A. J. HOWARD, informs us that the main effort, apart from dealing with problems put up by local industry, has been an investigation of the extraction of wax from peat on a pilot plant scale with a view to developing a process for the commercial production of peat wax. So far there have been no reports on this work as it is being carried out in conjunction with a local firm. Nevertheless, it is possible that further details will be published in due course.

Using Models to Track Causes of Explosions

IN recent years there have been several large firedamp explosions in British mines as a result of ignitions of gas that had accumulated either in roof layers or in cavities. Models are now being successfully used for studying these phenomena. This is essentially a matter of tracing the inflammation of non-homogeneous methane-air mixtures. Models are made from perspex and wood so that the flame is visible and little heat is lost during its propagation. Air, representing the ventilation flow in the mines, is fed to the model continuously. Methane is supplied from distribution chambers in such a way that the gas in the model is in a position corresponding with that which it is thought to have occupied in the mine at the time of explosion. The distribution system is so designed that the required quantity of gas can be introduced sufficiently rapidly to avoid serious complications due to molecular diffusion, but sufficiently slowly to avoid turbulent mixing with the air in the model. At the ends of the model are orifices for explosion release. *Safety in Mines Research* 1958* reports that when the various factors affecting the explosions, such as pressure release and point of ignition, are carefully controlled, the model shows a spread of flame similar to that known to have occurred in the mine explosion. The models have been used to examine qualitatively the effects of variations in some of these factors. The theoretical basis for the modelling is still far from complete, but the experiments have given hope that the behaviour of the flame in such models can be made to correspond with the full-scale event.

* H.M.S.O. 5s.

Pressure Loss in Preheater with Partial Evaporation

CALCULATION of pressure loss becomes more complicated when some vaporisation is taking place as in a preheater. This can happen in heating up petroleum fractions in a gas-heated pipestill. It becomes necessary to take into account that the degree of vaporisation of the oil—which influences the specific volume and hence the pressure loss—is determined by both the temperature and the pressure in each section of tube. A development of earlier methods for dealing with this problem and an equation for the pressure loss in these conditions, applicable to individual sections of tube, has now been put forward by DAVID GELBIN (*Chemische Technik*, 1959, Vol 11, part 12, p. 669). To help in applying it there is an accompanying phase diagram and a P-V diagram, both with constant enthalpy lines. The method of calculation also enables the temperature distribution in the preheater to be determined. This gives guidance on the risk of decomposition of the mixture and of formation of hot spots on tube walls. To illustrate the method there is an example worked out in detail for the feed to a secondary column in a petroleum refinery.

Is Chemical Cleaning of Plant Preferable?

COMPARED with mechanical methods of cleaning, chemical ones have a number of advantages. They can often be applied without dismantling equipment and can reach inaccessible places. Other assets claimed are that chemical cleaning is more uniform and avoids damage of metal surfaces. After discussing the matter in general terms, L. N. KLINGE and J. SELMAN have given* a specific example of methods used for cleaning a 16 tray column 64½ ft high with a diameter of 13½ ft. Over one to two hours water was introduced through a water meter and the line-up tested for leaks. During the next 4 hr, about 2000 gal. of inhibited hydrochloric acid were introduced. This was circulated for 8 hr, the temperature being raised to 60°C. Cleaning acid was run off and the column flushed with water for 6 to 8 hr. Flushing water was drained away and neutralised with caustic soda. Steam was led into the column then water and a 25% caustic soda solution until the liquid in the column had an alkalinity of 1 to 2% by weight. The diluted caustic soda solution was circulated for 1 hr. Finally the whole system including the circulation pump was flushed with water.

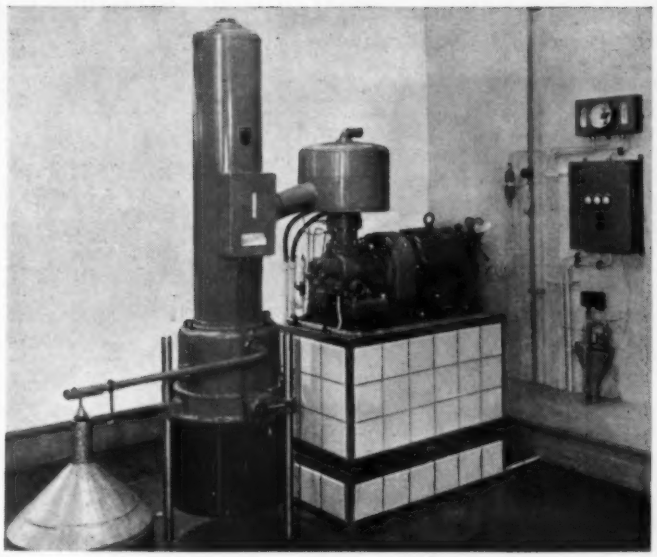
Variants on this scheme are proposed by the authors for cases where there are predominantly organic deposits, or for dealing with coolers, condensers, heat exchangers and auxiliaries such as tanks, pumps, valves. Potential corrosion difficulties are frankly faced with a warning of the need to test unknown inhibitors before they are applied and a cautionary example is quoted. To us it seems evident that great chemical care is needed if the method is really to score points in respect of the claim to avoid damaging equipment.

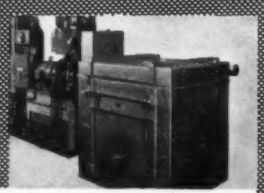
* *Corrosion*, 1960, Vol. 16, No. 1, p. 97.

Purifying Hydrogen by a Diffusion Technique

SO far the use of ultra-pure hydrogen produced by the palladium diffusion purifier has been largely restricted to the laboratory-scale or the manufacture of semi-conductors. Are there larger-scale special process applications where its use may be justified? The American firm Engelhard Industries, Inc., suggest producing ultra-pure hydrogen from by-product streams that contain appreciable amounts of hydrogen providing the contaminants do not affect palladium metal. The equipment is based on the fact that hydrogen will diffuse through heated palladium, but the metal remains impervious to impurities which may be present in the hydrogen.

There are many hazards involved in the use of these diffusion tubes and the model exhibited at the Physical Society exhibition by the British branch of the firm was designed to eliminate them. If hydrogen is allowed to be in contact with palladium during heating or cooling through a critical temperature around 150°C, rapid deterioration of the metal will take place. An important feature of the unit is, therefore, a series of electrical interlocks to prevent this. Impurities such as water vapour, oxygen and nitrogen liable to be found in cylinder hydrogen do not accumulate on the high pressure side of the tube, but are bled out by a controlled flow of impure hydrogen and either burned off or vented to





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atmosphere. If these impurities were allowed to collect in the system they would soon poison the surface of the palladium with a consequent reduction in the rate of diffusion.

The hydrogen bleed-off loss is normally 5-6% of the total gas flow through the unit whether it is dealing with trace impurities as in cylinder hydrogen or separating a major constituent as in "cracked" ammonia. Impurities remaining in the outlet gas are below the limits detectable by any normal analysis method, and water vapour is removed as completely as other impurities. The makers claim that because of the elaborate devices built into the purifier this unit will have an almost indefinite life provided it is not subjected to poisons such as sulphur compounds.

Fresh Prospects for Industrial Fermentation

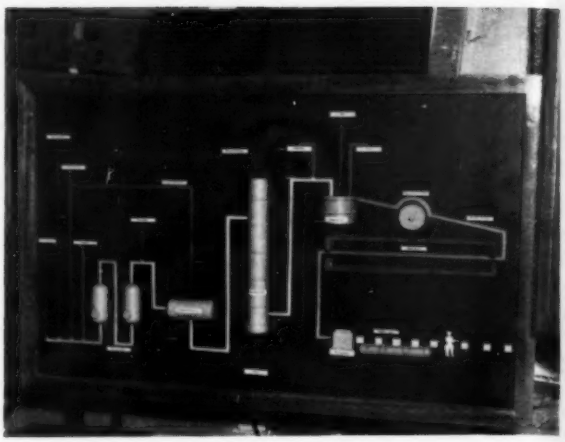
IN the biochemical laboratories to be built at Imperial College, PROFESSOR CHAIN—joint Nobel prize winner for work on penicillin—plans to carry out academic research on the 2000 litre scale. His new building, to be known as The Wolfson Laboratory, will include equipment and facilities not usually associated with departments of biochemistry. In particular it will house fermentation units of comparatively large size and workshops for advanced mechanical and electronic equipment. The main fields of work will be training and research "in the neglected borderland between biochemistry and chemical engineering," and research on an adequate scale into biochemical production.

In reply to our questions on the advantages—in terms of pure research—of working with larger quantities PROFESSOR CHAIN made a number of illuminating points. The fact that work has previously been carried out on the test-tube scale has proved expensive. Interesting things happen which can only be satisfactorily detected when the work is on an industrial scale. If the yield of a product is of the order of micrograms per litre it may be overlooked in test-tube amounts of material or very difficult to work with. Furthermore, fermentations may develop in different ways in thousand-litre quantities. For example, in normal laboratory apparatus a broth is oxygenated by using a stirrer. But this also gives a shearing action and some moulds are sensitive to shearing. Working with large equipment, however, it is possible to separate the two kinds of treatment. This produces new fundamental knowledge. An important current interest is in producing alkaloids by processes giving good yields, for example up to 2g/l of the ergot type.

So far, in fermentation processes we have made use only of end-products of plant metabolism. In these newly-developing programmes it is hoped to delve deeply into the mechanism of making the products, so that new compounds can be isolated, new catalysts found, as a possible basis for future large scale production. Will this work tend to stem the declining interest in industrial fermentation processes?

Designing Welded Pipe Fittings

IF designs are to be more economical, and therefore more critical, the design stress approach must be supplanted by a less empirical method. This should treat with discernment the true physical conditions which each part has to sustain. In effect, this was the finding of Commission XI of the International Institute of Welding, set up to consider problems of pressure vessels, boilers and pipe lines. The corollary of this approach is that the full economic advantage of welding is not available until there is a better understanding of the stress systems arising in the equipment to be designed. For piping components a new booklet* summarising the present state of knowledge helps to provide this information. It gives details of extensive stress measurements on pipe bends, or welding elbows. VON KARMAN'S classical method of calculating the stresses has been extended to be applicable to short-radius and thin-walled bends which have been increasingly used in recent years. The experiments have confirmed the validity of the proposed calculation.



Illuminated flow diagram of styrene-butadiene rubber production displayed in the Industrial Chemistry Gallery of the Science Museum, London. The diagram—showing the emulsion polymerisation process—forms part of a permanent exhibit which the British Rubber Industry has recently presented to the Museum.

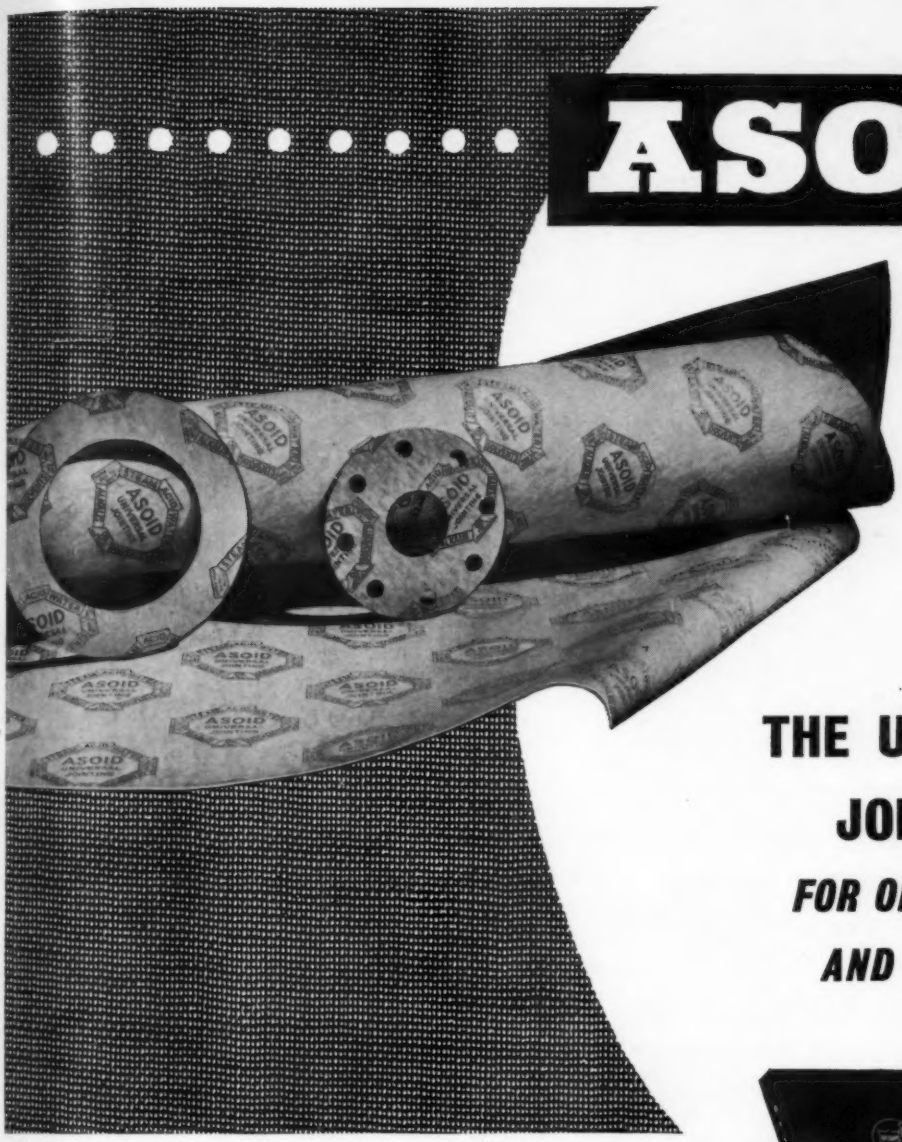
Stress measurements on fabricated branch connections are also described. These give a rational basis for comparing the effectiveness of various forms of reinforcement proposed or in use. A further section deals with fatigue strength of pipe butt joints, and of various designs of end closures for model headers. From this work, important conclusions have been drawn concerning detail design of welds to attain maximum efficiency, and the importance of various classes of defect. A foreword is supplied by PROFESSOR H. FORD of London University and a final section gives guidance on applying the research data in practical design.

Bound in to the booklet is a folder of stress diagrams for an unreinforced branch connection and a reinforced one. These are shown with axial loads on the branch, in-plane bending, out-of-plane bending, twisting, and internal pressure.

* "Design of Welded Pipe Fittings." Prepared by P. H. R. Lane and R. T. Rose. British Welding Research Association. 15s.

Trade Effluents Report: Comments Invited

THE chemical group of industries are such heavy users of water and such a profuse source of effluents that they are certain to pay special attention to the Final Report of the Trade Effluents Sub-Committee (H.M.S.O. 3s. 6d.) In this document important changes in the law relating to the discharge of effluents into rivers and sewers are suggested. The report is critical of the law dealing with existing discharges since it does not define pollution, although making it a criminal offence to discharge a polluting effluent. As an alternative to a general standard or definition, which they thought impracticable, the sub-committee recommended that each discharge should be judged individually, on its merits. New discharges are already treated in this way under the 1951 Act.* For this purpose dischargers should be required to seek from their river board permission to continue their discharges. The board should have power to grant permission



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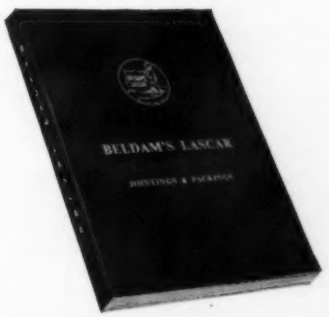

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subject to conditions. This approach, it is suggested, will permit "control of river pollution with justice to the discharger and to the river."

Replying to a question on the report in the Commons, MR. BROOKE, Minister of Housing and Local Government, stated that his first step must be to consider any comments which interested bodies may wish to make on the general principles of the report, particularly bodies representing industry, the local authorities and the river boards. He hoped that any such comments would reach him promptly.

• Rivers (Prevention of Pollution) Act 1951.

Hydrometallurgy "Down Under"

A WIDE ranging set of papers on hydrometallurgy is being presented at a symposium organised by the Adelaide Branch of the Australasian Institute of Mining and Metallurgy. Solvent extraction, the hydraulic cyclone, ion exchange, mixer-settlers, sedimentation units, mixing, flocculation processes all receive attention.

An unusual line of work is reported by R. C. CANNING in developing a solvent extraction process for the recovery of scandium, yttrium, thorium and heavy lanthanides from complex low grade sulphate solution. The raw material is the waste liquor from the Port Pirie Uranium Treatment Plant. Known solvents for these elements include tri-alkyl phosphates—effective only with nitrate solutions—and the more recently developed alkyl-phosphoric acid esters which are applicable to sulphate solutions. Mr. CANNING states that a kerosene solution of di-(2-ethyl-hexyl)-phosphoric acid has been found suitable for separating individual lanthanides. Scandium, in particular, may be recovered as a high grade oxide product. The process is likely to be extended so that the individual heavy lanthanides, yttrium, and thorium can be obtained. The work has been taken up to the small pilot-scale.

The symposium secretary, MR. P. K. HOSKING of the Australian Mineral Development Laboratories, tells us that to obtain full copies of all papers it is necessary to register as a delegate and pay the fee of £3 (Australian).

Get the Most from Your Instruments

FORMULATED after discussion with users and makers, an "instrument specification philosophy" published in *Petroleum Refiner* (1959, Vol. 38, No. 12, p. 89) is of exceptional interest. Background to the project was the desire to deal with misunderstandings between client and contractor, with shortages of control engineers and variations in methods of approach. The resulting general specification embodies a modification of Instrument Society of America Recommended Practice ISA RP 5.1. For each project it is recommended that the following data should be supplied: instrument lists, material specifications, manufacturer information, instrument installation drawings, instrument tubing drawings. But in addition to this direct instrument information, piping assembly drawings, architectural drawings and electrical conduit drawings are also wanted. Requirements for each of these are then further specified.

Chemical analysers have been excluded from the general specification. It includes, of course, instruments for measuring flow, pressure, temperature and level. Transmitters and receivers, control boards, controllers and control valves all receive detailed attention. It is a measure of the thoroughness of the compiler, W. E. BUSHNELL, that he includes relief valves, rupture discs, tubing and wiring. His concluding section covers sealing, purging and what is called winterising. Each of these sections is in turn broken down to deal with specific and individual requirements.

What Goes On at Warren Spring Laboratory?

THE youngest D.S.I.R. laboratory has just published a new description of its scope and functions. Bringing up to date the preliminary notes issued at last year's official opening the booklet refers to current investigations planned to provide data to facilitate design of distillation columns, gas absorption towers and reaction vessels of the liquid phase type. Although the Warren Spring Laboratory has wide terms of reference it confesses to a "bias" in its field of work. This is in the direction of chemical engineering and pilot-scale work for which it is extensively equipped. The basic programme of work is intended to benefit industry and the community in general, but the Laboratory is also willing to undertake sponsored work for individuals, firms, and Government departments.

In the Intelligence section the station is preparing to make technical and economic assessments of research projects to determine their potential economic value. It is also hoped to indicate the most economically promising lines of research and development. We understand that the section would welcome suggestions from industry both on what cost information is desired and what it is legitimate to investigate without seriously infringing commercial secrecy. It seems possible that all branches of chemical and plant production might agree that costing of unit operations for publication should be attempted as a general service of wide value. We should be glad to have readers' views on this subject.

"Plasma Arc" Torch

OPERATING at temperatures of a different order from those in Zeta, a "plasma arc" torch nevertheless uses pinch effects in some ways comparable with those which Harwell's great machine first brought to public attention. It has correspondingly achieved temperatures far above those of normal arcs or flames.

At I.C.I. Metals Division at Witton—where they are exploring the possibilities of the method—we recently saw a demonstration of this torch. Apparently the first reference to it in the literature was published by R. M. GAGE in the *American Welding Journal*, Vol. 38, No. 10, October, 1959. The arc is struck between two electrodes inside a water cooled copper chamber. One electrode is in the form of a small diameter orifice. A stream of inert gas passed through the chamber at high velocity issues from this orifice as an electrically neutral stream of ionised gas particles. The high velocity of the gas in conjunction with the external water cooling has the effect of lowering the conductivity of the gases at the periphery of the stream. This confines the current to the inner portion producing a so-called "thermal pinch effect" which increases both the temperature and conductivity. When the current density in the inner portion of the arc reaches a certain high value by this means, there is a further increase in current density due to the self-induced magnetic fields of the charged particles moving in the same direction. These effects produce an arc of very high intensity and temperatures of 60,000°F have been claimed.

MR. S. S. SMITH, Research Manager, and MR. C. A. TERRY informed us that the plasma stream is capable of transferring heat more rapidly than any other known flame and, moreover, can transfer large amounts of heat without falling in temperature. The gases which can be employed in the system

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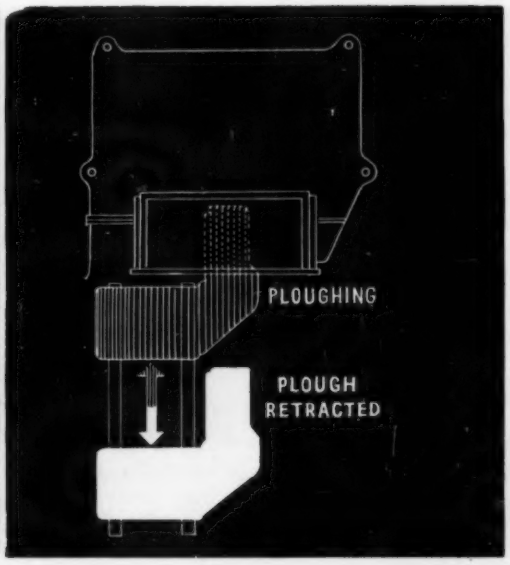

Second Draft of Special Regulations for Ionising Radiations in Factories

TAKING into account both earlier comments and the recommendations of the International Commission on Radiological Protection, a revised draft has been issued of the Factories (Ionising Radiations) Special Regulations. This includes a new schedule of permitted radiation doses and a changed definition of 'adequate shielding.' The Ministry of Labour invites further observations to be sent in by 15th April, 1960.

are normally limited to hydrogen and nitrogen which have no significant effects on the life of conventional electrode materials such as tungsten. Nevertheless in certain studies, air has been passed through such a torch. Equipment of various types has been made experimentally in America and used for spraying of refractory oxides and borides or metals such as tungsten and molybdenum.

Crystallising Calcium Nitrate in Mineral Oil

AFTER critically considering methods of making calcium nitrate in a stable form attractive for use as a fertiliser, P. J. VAN DEN BERG and G. HALLIE developed a completely new procedure. It is based on crystallising droplets of calcium nitrate in a mineral oil to which seed crystals have been added. After crystallisation the solid prills and the oil are separated by centrifuging.

Investigations in the laboratories and pilot plants of Dutch State Mines showed that the process had two major advantages. Controlled crystallisation in a medium with excellent heat transmission properties made it possible to manufacture prills of a regular shape and desired size, while the height of fall in this medium is very small. But, in addition, after centrifuging the prills are still coated with a thin oil film. Addition of special substances to the oil therefore makes it possible to obtain a film which reduces the rate of moisture absorption considerably and gives the prills a dry appearance. Dust formation is suppressed, and the product has excellent storage and handling properties.

In a paper presented before the Fertiliser Society, the plant was described as having two main circuits—one for taking the solution up to the prilling stage and then the oil circuit. The calcium nitrate solution obtained from the nitrophosphate process is first evaporated to the desired nitrogen content and raised into a storage tank. It passes through a levelling vessel and is fed to the prilling cup. This is a conical or cylindrical perforated cup rotating on a vertical axis where the solution is prilled to form drops of the desired diameter which fall into the oil tank. The drops transmit part of their heat to the oil and solidify. The prills are discharged from the prill vessel through a valve, then centrifuged and bagged. The oil goes to the oil collecting tank, then to a settling tank to deposit dust, through a heat exchanger and back to the prill vessel.

DIARY

The Institution of Chemical Engineers

February 23. At The Geological Society, Burlington House, London, W.1. "Vibratory Ball-Mills," by H. E. Rose. **5.30 p.m.**

March 9. *Scunthorpe Group.* At Berkeley Hotel, Doncaster Road, Scunthorpe. Annual Dinner and evening symposium on "Filtration." Dinner **5.45 p.m.** and symposium **7.30 p.m.**

March 9. Joint meeting of the North Western Branch with the North Western Centre of the Graduates and Students Section. At The Houldsworth School of Applied Science, University of Leeds. " Recent developments in heat transfer," by O. A. Saunders. **7.0 p.m.**

March 22. At the Geological Society, Burlington House, London, W.1. " The flow of granules through apertures," by R. L. Brown. **5.30 p.m.**

March 29-31. *North Western Branch.* At Manchester. Symposium on "Chemical process hazards with special reference to plant design."

The Society of Instrument Technology

February 23. At 26 Portland Place, London, W.1. "Backscatter method of wall thickness measurement," by D. F. White and L. E. Taylor. "Ultrasonic resonance method of wall thickness measurement," by M. V. James. **6.30 p.m.**

March 16. At 26 Portland Place, London, W.1. "The simulation of a large chemical plant on an electronic analogue computer," by A. M. Doveton and K. C. W. Pedder. **6.30 p.m.**

The Institution of Mechanical Engineers

March 9. At 1 Birdcage Walk, Westminster, London, S.W.1. "Power, Flow and Pressure Measurements in Pumps Testing," by L. Young and R. A. Nixon. **6 p.m.**

March 10. At 1 Birdcage Walk, Westminster, London, S.W.1. "The use of models in layout production." Discussion, Industrial and Administration Group. **6 p.m.**

The Chemical Society

March 16. At Kings College, Newcastle-upon-Tyne. "Progress in the study of heterogeneous catalysis," by Professor C. Kemball. **5.30 p.m.**

The Institutions of Civil, Mechanical & Electrical Engineers

March 3. Joint Meeting. At the Institution of Electrical Engineers, Victoria Embankment, London, W.C.2. "The engineer and civilisation," by Sir Hugh Beaver. **6 p.m.**

The Institution of Civil Engineers

March 22. At the Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1. "Plastics in Engineering," by R. Beeching. **5.30 p.m.**

The Institute of Petroleum

March 2. At 61 New Cavendish Street, London, W.1. "Corrosion problems in the Lacq Field," by Michel Estavoyer. **5.30 p.m.**

March 22. At 61 New Cavendish Street, London, W.1. "Technical Education in Russia," by Professor H. Levy. **6 p.m.**

The Royal Institute of Chemistry

March 3. At Medway College of Technology, Maidstone Road, Chatham. "The use of platinum catalysts in petrol refining," by J. M. Pirie. **7.30 p.m.**

Other Events

March 22-25. At Central Y.M.C.A., Snow Hill, Birmingham 4. 4th Annual Midlands Instrumentation Exhibition and Lecture Programme.

CONTINUING RAPID GROWTH OF BRITISH CHEMICAL INDUSTRY

ON page 157 we refer to the growth of chemical production in the OEEC area as a whole during 1958. For Britain alone, more recent information is available. This shows that expansion continued vigorously in 1959. On the basis of 1954 figures being taken as 100 the index of industrial production was 115 in the year 1958 for the chemical and allied industry compared with 107 for all manufacturing industries. The monthly average for the eight months ending August 1959 stands at 125 against 111 shown for all manufacturing industries. The gross output of the chemical industry in 1957 (the latest available absolute figure) amounted to approximately £2,200m. These are among the figures given in the Annual Report of the Manchester Chamber of Commerce (Chemical & Allied Trades Section). The report goes on to note that special attention has been given by the Association of British Chemical Manufacturers to productivity. Researches continued through the post war period have produced some impressive results. Productivity of the chemical industry is progressing at twice the rate of manufacturing industry as a whole and is now over 60% above that for 1948. This increase has been accomplished with only a 22% increase in the labour force. Labour relations within the industry continue to be free from trouble. Towards the end of the year the chemical trade as a whole decided to adopt a working week of 42 hours instead of the 44 hours worked previously. Roughly £22m. was spent on research and development in 1958. This was nearly 10% of the total expenditure for this purpose in industry as a whole.

The United Kingdom is the third largest exporter of chemicals; in 1958 her percentage share of world trade in this commodity was 15.3. Chemical exports—accounting for nearly 10% by value of all British exports—in the first eleven months of 1959 were valued at £266.08m., an 11% increase on the amount earned in the same period of 1958. The record figure of 1957 has been exceeded. However, growing competition has dictated a need for price concessions and profitability particularly in fine chemicals has in many cases declined. Competition is particularly severe from Western Germany whose share of world chemical exports has steadily increased. Outstripping the United Kingdom in 1954 her exports are second only to the United States which since 1952 has steadily accounted for 28.5%.

The movement to free trade in Europe is confidently awaited by the U.K. chemical industry. Western Europe is the world's largest market for chemicals and is still rapidly expanding. At present our exports of chemicals to that area account for some 28% of the total. In general, industrialised countries are taking an increasing proportion, whilst exports are declining to less developed areas which are liable to impose import controls from time to time due to balance of payments difficulties.

Turning to an individual section of the industry, it is interesting to note that exports of pharmaceuticals in 1959 showed a moderate increase over the previous years. Proprietary medicines, besides being the largest product group in value, made the most substantial contribution to this increase. Improvements were also registered in a number of other groups and most notably in vitamins, alkaloids and ointments. On the other hand, setbacks were experienced in four of the groups, namely the barbiturates and insulin and more significantly in the antibiotics and sulponamides. The last two suffered throughout the year from sustained price competition, particularly from European sources.

Advances during the year have included the development of griseofulvin, a new antibiotic discovered by Britain. This possesses the novel property that given orally it has a powerful action against fungal skin infections. A further development has been the successful use of new low dosage sulphonamides. This group of drugs has been successfully used for several years for the treatment of bacterial infections, but high doses have had to be administered every few hours. The new compound permits effective treatment with one dose per day.

Research has been maintained at a high level and promising leads in the penicillin field have been reported.

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Process Control—Uneven Progress

THE past year has seen a profusion of conferences, exhibitions and symposia, both at home and abroad, devoted to some aspect or other of automatic process control. It is interesting to look briefly at what has emerged from these various events, to see how it measures up to present-day demands, and how the two main factors in control—instrumentation technology and process dynamics—are affected.

In the instrumentation field one obvious trend has been the growth of measurement techniques. Instruments which yesterday had reached the status of production control laboratory tools have today become key components in automatic-control, closed-loop systems. Among the growing list of such instruments are to be found the infra-red and ultra-violet spectrometers, refractometers, vapour-phase chromatographs, and, as the recent Physical Society Exhibition revealed, polarography and X-ray spectrometry too have become control-loop instruments. The advance in optical instruments has been accompanied by a continued improvement in electronic control equipment, and the combination of the two has provided a number of reliable, responsive and accurate tools for process control. Photo-electric instruments are typical products of this successful marriage.

The big question is whether the ability to apply such instruments has kept pace with their development. It is impossible to deny the value of a knowledge of instrumentation hardware, but unless the engineer also possesses an understanding of the operational principles of controllers, servos, and so on, then he is ill-equipped to make technical decisions about the control of processes. This brings us to the second factor in automatic control—the response of systems to disturbances, or, in other words, their dynamics.

For the solution of many of the control problems he has encountered, the chemical engineer has up to the present made use of a number of principles. There is, for example, the flywheel principle, which has been widely used in modern processes to provide operational flexibility. Next might be listed the principle of self-regulation, which allows effective use to be made of some unusual operating characteristic for the purpose of open-loop control. Finally, there is the principle of environmental control, the underlying philosophy of which is that if all the inputs to a system can be controlled, then its output also can be controlled. For a number of reasons, it is unlikely that these well-tried methods will suffice in the future. Take but two sides of the problem of obtaining greater return on processing investment, the achieving of greater productivity and of improved product quality.

In many instances the productivity of a plant can be raised through more intensive operation at higher temperatures and concentrations. Measures of this kind make a process faster acting and more sensitive to upsets. Consequently the control arrangements have to be more accurate and quicker to respond. In many cases, too, the aim of better product quality may demand a reduction in hold-up time. This revision leads to lower process time-constants which, in turn, require more rapid corrective action. Such aims as these call for higher levels of performance in process control, and control schemes for achieving them are becoming a factor of immense importance to the process industries.

So far as the second factor in automatic control is concerned, during the past year there has been a considerable concentration upon the dynamics of processes. But most of the contributions in the field have not been relevant to the chemical and process industries, although during the year a number of papers were presented under the auspices of the Institution of Chemical Engineers, the A.I.Ch.E. and the A.S.M.E. which did much to make the picture less gloomy. Nevertheless, only the simplest control loops can at present be dealt with satisfactorily, and it is doubtful, unless some really outstanding advances are made, whether the new techniques in measurement or computer control can be used to the fullest advantage. It is possible that the volume of new ideas crossing over from other industries—something which cannot be predicted—may provide some much-needed impetus in this direction.

Much has been written about work on optimising controls, systems in which an automatic controller adjusts itself to produce the best results from the process which it is attempting to control. In this field are the "learning machines", but as things are at present they are much too expensive and their learning capacity is limited. However, in the digital computer there is a tool which may well provide a limited form of optimising control, and in this field there was one notable event during the year, the control of a polymerisation process by Texaco by means of a digital computer developed by Ramo-Wooldridge.

In view of achievements of this kind—this one is still shrouded in some mystery—we are apt in this country to bemoan the fact that in some spheres of automatic control we appear to lag behind other countries. This, however, does not hold in the application of automatic control methods to mass-production machinery, a field in which we can claim to be second to none. However, in the chemical field there is a noticeable tendency to adopt devices and techniques developed outside this country, which in itself suggests a tendency to lag behind. While it would be harmful not to make use of the most advanced practical and theoretical developments from abroad, considerable benefits would be gained if the country were to attain in the process control field a position comparable to the one it occupies in the control of mass-production machinery. But we have advantages that are not always recognised; our diversified engineering industry with its close relations with the processing industries offers exceptional opportunities for close working between the parties interested in problems of automatic control.

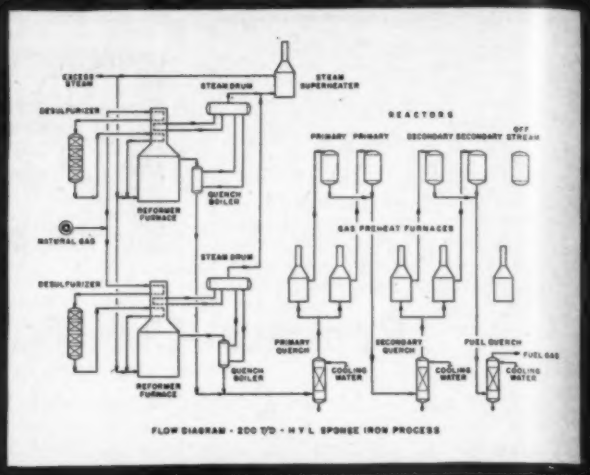

Fig. 2. Flow diagram of 200-tpd HyL sponge iron plant brought into operation during November, 1958.

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THE "HYL" SPONGE IRON PROCESS

by R. LAWRENCE, Jr.

HOJALATA Y LAMINA S.A.—one of Mexico's leading steel producers—has developed a new sponge iron process which has operated with complete commercial success since November, 1958, in a 200-tpd plant at Monterrey, Mexico. Since January, 1959, the plant has operated at 95% of rated capacity. The new process, designated "HyL" (Hojalata y Lamina), was developed with engineering assistance from The M. W. Kellogg Co., New York—designers of the 200-tpd plant and exclusive world-wide licensing agents for the new process. Kellogg is now engineering and constructing a second and larger plant (500-tpd) for Hojalata y Lamina adjacent to the site of the first plant. This plant is scheduled for on-stream early this year.

HyL sponge iron, a high-quality metallic, can be charged directly in electric steel-making furnaces. This fact, plus the wide-scale availability of the two basic HyL ingredients (natural gas and iron ore) and the low capital investment and operating costs required for HyL plants combine to make it one of the most useful new vehicles for steel-industry development or expansion in many parts of the world.

Direct Reduction by Gases

HyL is a batch process in which lump ore is reduced in a retort by hot, reformed natural gas. The main sections of the 200-tpd sponge iron plant consist of a pair of Kellogg gas-reforming furnaces (where the medium for ore reduction is prepared) and a row of five equal-sized reduction reactors, each with a capacity of 13 long tons of ore. Since early test melts of sponge iron showed that 85% reduced iron gave a good economical balance for production of satisfactory steel ingots, the 200-tpd plant was designed to reduce ore to this degree.

The medium for reducing iron ores via HyL is a gas which derives from natural gas. Natural gas is first directed through preheating coils in the reforming furnaces, then through a desulphurising drum, and finally through the main reformer tubes, where it reacts with superheated steam to produce hydrogen and carbon monoxide in the presence of a catalyst. The hot gas leaving the reformer section of the furnace is cooled as it passes through a waste heat boiler located in the furnace stack and from there to a scrubbing tower, where it is quenched.

Four-hour Reduction

On entering the ore-reducing area of the plant, where the five reactors are located, the cool, dry gas is first preheated in special-design tubular preheaters to the proper ore-reduction temperature. At this point it is designated "primary" gas and is ready to reduce ore in the two reactors which are in the "primary" position during the plant cycle (see Chart A).

After it has passed through two of the reactors for approximately two hours, the primary gas is considered "secondary". It receives a secondary water quench to remove water formed in the reduction reaction; it is reheated, and then passed for a second two-hour period through two reactors which have been loaded with fresh ore. Thus, the "secondary" gas is used to both pre-heat fresh loads of ore and initiate the reduction process. In the five-hour plant cycle, one of the reactors is off-stream at all times.

Mr. Lawrence, Jr., *is a Member of American Society of Mechanical Engineers; American Institute of Mining, Metallurgical and Petroleum Engineers. He has been 15 years with Kellogg as Departmental Head, Mechanical Engineering Division; Manager, Piping and Pressure Vessel Sales, Fabricated Products Division.*

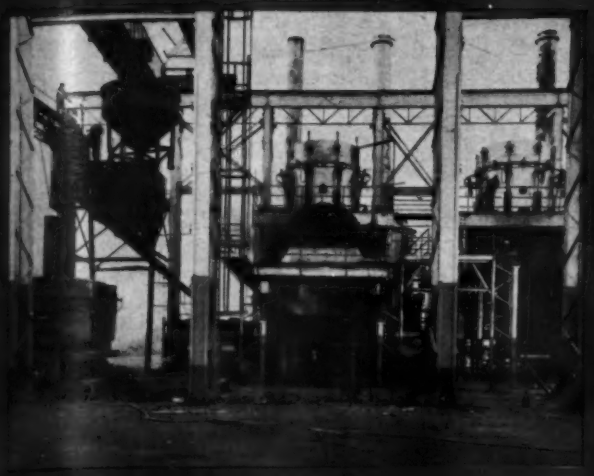


Fig. 3. The discharge of sponge iron from one of the five reduction reactors at the plant.

Fig. 4. Economy in pipework design is shown in this view of the preheater section of the plant.

A recent process for iron-making derives its iron-ore reducing agent from natural gas

How Fifth Hour is Spent

The off-stream reactor, loaded with sponge iron that has been reduced during a four-hour gas flow, remains off-stream for approximately one hour. Before it is unloaded of sponge iron and reloaded with fresh ore which is briefly purged with natural gas, the temperature in the reactor is lowered to the proper point where an injection of natural gas will cause cracking and deposit additional carbon in the pores of the sponge iron. This carburisation stage takes only 2 to 3 min.

Centralised Plant Controls

At the 200-tpd HyL plant each reactor is directly connected to its own reduction gas preheater and its own quench zone. Remotely-operated valves and a cycle control system with safety interlocks minimise operating hazards and the entire reduction process for all five reactors is controlled from a central control house. Dumping and loading are directed from an outdoor platform. The reduction reactors are designed in two sections with a stationary flanged top head to which the inlet gas connections remain permanently attached. The lower sections, also flanged, can move on wheels to discharge points where they are tilted to dump their cargo of hot sponge iron into an open-top transporting hopper which also serves as a charging bucket for the electric furnaces.

Sponge Iron Analyses

Sponge iron has been produced ranging from 75 to 95% reduction. The average sponge iron quality can be maintained within 1 or 2% of the design figure when desired. Typical sponge iron analyses taken at different levels through the reactor bed are tabulated below:

	0–1 ft	*1–2 ft*	*2–3 ft*	*3–4 ft*	*4–5 ft*
Metallic iron ..	90.0	86.8	79.4	73.0	64.0
Total iron	93.4	93.0	90.8	89.8	87.4
% Reduction ..	96.0	93.3	87.4	81.3	73.2
Carbon	1.3	1.36	1.64	1.62	1.34
Sulphur	0.06	0.02	0.04	0.03	0.02
Insolubles ..	3.1	3.5	3.6	3.5	3.5
Average % reduction by analysis					86.2
Calculated % reduction by wt. loss					96.0
Calculated % reduction by gas atom balance ..					87.4

Essentially the HyL process does four things to the iron ore:

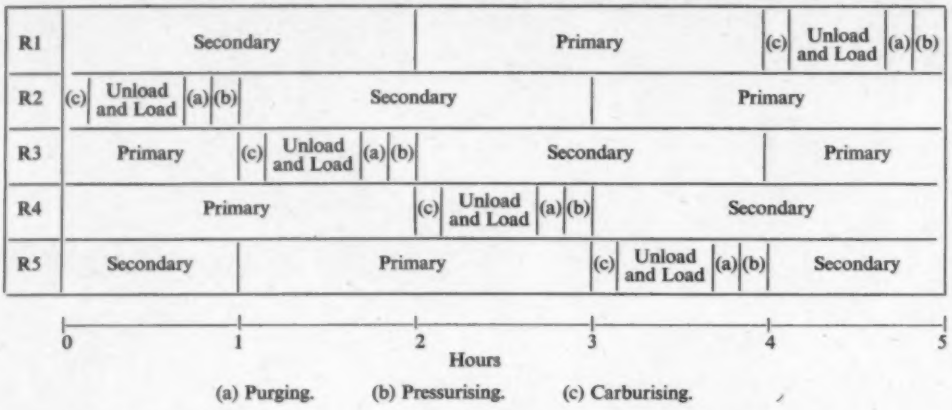
(1) it removes all water and calcining loss;
(2) it removes a high percentage of oxygen;
(3) it removes a high percentage of sulphur; and
(4) it deposits carbon in the sponge iron.

The water and calcining losses are removed from the ore during the heating period in the secondary position. Since excess heat is available at this stage, the process is not penalised by high water content of the ore. In fact the plant has operated for extended periods with ores that were dripping wet.

Oxygen removal may be completed to almost any degree desired up to about 95%. The exact percentage will be a function of the gas quantity, the cycle time and the temperature in the reactor. Various ores have different characteristics which will set the economical limit for the maximum per cent reduction. Sintered ores tested in the plant have been reduced to essentially the same per cent reduction as Mexican ores.

The 200-tpd plant removes sulphur from the iron ore as hydrogen sulphide. It gives a product less than 0.06 wt. % sulphur, provided the sulphur content of the ore is less than 0.5 wt. %. The plant has a capacity to remove much more sulphur but will not give a final product of the low

CHART A—HyL PLANT CYCLE OF FIVE ORE-REDUCTION REACTORS



(a) Purging. (b) Pressurising. (c) Carburising.

sulphur content required for making steel of a 0.04% sulphur content. Where higher sulphur in the steel is acceptable, the sulphur content of the ore charged to the unit may be higher without necessitating reducing sulphur in the steelmaking process. The steelmaking furnaces must be prepared to reduce phosphorus if a high-phosphorus ore is used, since the HyL process itself does not facilitate phosphorus removal.

Ores and Gas

The 200-tpd HyL plant at Monterrey is supplied with rich ores from Durango and Pihuamo. The exact ore composition varies slightly, of course, but a Pihuamo ore sample provides a fair average. It contains about 65% iron −20% magnetite and 80% hematite. Other high-iron ores in which 40% appears as magnetite have also been successfully reduced in the Mexican plant. The sponge iron reduction for both types proved essentially the same. Tests are now in progress in processing ores of lower iron content.

Before it is dumped in the reactors the Mexican ore is crushed and screened to sizes ranging from ¼ to 1½ in. Up to 20% of the ore charged is −¼ in. A higher precentage of fines would prevent proper passage of the reducing gas through the ore, while a greater quantity of larger lumps would not be as amenable to rapid reduction. A study of agglomerating fine concentrates is now under way. Preliminary results indicate that a low-cost pelletising plant may be possible.

An avervage analysis of the hydrogen-rich reducing gas is as follows: 6.6% CO_2, 16.3% CO, 73.1% H_2 and 4.0% CH_4. About 21,000 net cu. ft of natural gas and some 70 kVA of power are currently required to produce one net ton of sponge iron in the 200-tpd plant.

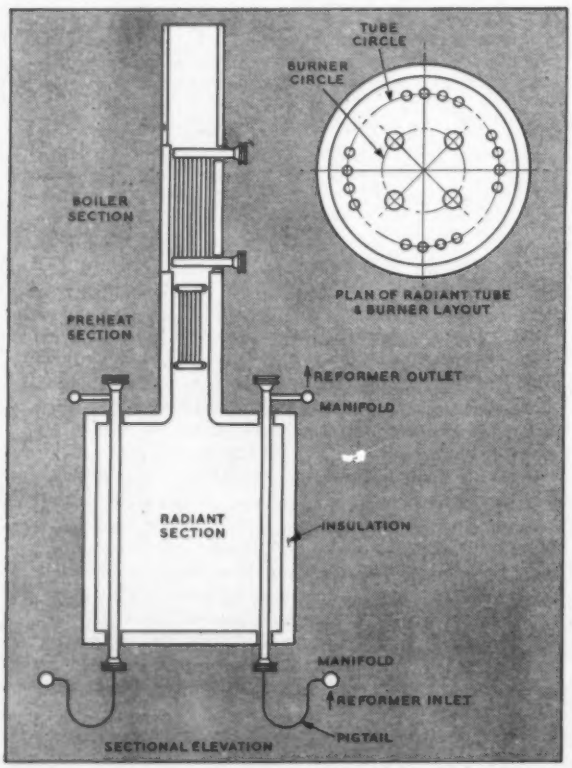


Fig. 5. Cross-section diagram of the gas reformer furnace and plan view of the radiant tube and burner layout.

HyL Sponge to Steel

The melting technique now employed at Monterrey is is follows: A small quantity of scrap is first charged on the bottom of the furnace and all sponge iron is then charged high along the walls and low in the centre. Electrodes are introduced and burn through the sponge iron down to the scrap at the bottom, and the material is melted from the bottom up in normal fashion. The initial silica or acid slag is removed while sponge still remains on the bank above the slag line. After this slagging-off, the balance of the scrap is added and the melt is completed. Normal electric furnace operations then proceed. The melt requires approximately the same time as an all-scrap charge.

The metallic yield of the steel produced at the Hojalata y Lamina facilities is essentially the same, whether scrap or sponge iron is used. Tonnage of steel produced per heat is also comparable. On the 75-ton arc furnace, an average of 4½ heats per 24-hour day were made on the all-scrap charge, and the same number are now being made on the 50% sponge-50% scrap charge. The plant's steel production capacity has thus remained of the order of 300,000 net tons of ingots per year. When the new 500-tpd sponge iron plant is in operation, of course, total tonnage of production will increase.

In practice, the amount of power consumed in melting sponge at Hojalata y Lamina is only slightly over that required for melting 100% scrap iron. Furthermore, power requirements for melting sponge are much more uniform. When sponge iron is charged, voids are reduced, thus avoiding energy radiation to the refractory linings of the furnaces.

An electric furnace consultant to HyL and Kellogg recently made test melts in which the sponge iron content of the furnace charge was varied. The following results were obtained:

20,000-kVA LECTROMELT FURNACE—70 METRIC TON CHARGE

	Time to Melt (min.)	*Melting Rate (tons/hr.)*
50% Sponge	151	27.7
70% Sponge	174	24.2
100% Sponge	180	23.0

High-quality Steel Product

Hojalata y Lamina is using the steel produced from its HyL sponge for producing deep-drawn steel products such as cooking utensils and electric resistance welded pipe. The steel is high quality and is directly comparable in physical and chemical specifications to rimming steels. One of the reasons why Hojalata y Lamina is enthusiastic about melting sponge iron as compared to scrap is the virtual elimination of difficulties formerly encountered in keeping residuals low. With a 100% scrap-iron charge to the electric furnaces, copper and nickel residuals were particularly difficult to maintain at low levels. Now, with a 50% sponge iron charge heats which are off-specification have greatly decreased.

In the ultimate economic measurements the new HyL sponge iron process presents a favourable picture indeed. The capital investment required for each year-ton at Hojalata y Lamina's 200-tpd plant at Monterrey, Mexico, is estimated at $45. This figure is perhaps the lowest investment cost required for any of the seven known iron-ore reduction processes now in commercial use in different parts of the world. In comparison with current investment costs for blast furnaces, for example, HyL investment costs come out at least 50% less.

Operating costs for HyL plants over other types of reduction plants are equally attractive economically in favour of HyL. At the present 200-tpd HyL plant only eight operating personnel per shift are required to operate all facilities. This is considerably less man-power than in comparable plants using other ore reduction processes.

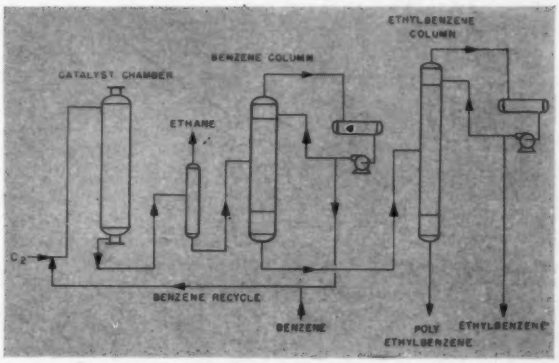
Manufacture of Ethylbenzene by means of a New Catalyst

A NEW-TYPE solid phosphoric acid catalyst has been developed recently, and is currently in commercial use, for the production of ethylbenzene and cumene. This catalyst is designated as UOP # 4 polymerisation catalyst and differs considerably from earlier solid phosphoric acid catalysts. Although the new catalyst is also useful for polymerisation, when used for ethylbenzene production it has higher activity toward the primary alkylation reaction and lower activity toward the undesirable polymerisation side-reaction under these conditions. The alkylation activity of the catalyst gives ethylene conversions as high as 98.7%. The charge to the process is a C_2 and lighter gas stream (containing 29% ethylene obtained from a propane cracking unit) and high-purity benzene. Polymerisation of ethylene when producing ethylbenzene is not appreciable and higher boiling alkylbenzenes are negligible.

The ethylbenzene unit, which was designed and licensed by Universal Oil Products Co. for the El Paso Natural Gas Co., Odessa, consists of a feed absorber, reactor, gas separator, benzene fractionator and ethylbenzene fractionator. Fig. 1 shows a flow-diagram of this unit. The feed absorber takes the total C_2 and lighter gases from the propane cracking unit, absorbs them in benzene, and the resulting liquid is then passed through the feed heaters into the solid phosphoric acid catalyst. From this reactor effluent stream, the C_2 and lighter gases are separated, the benzene fractionator removes the benzene which is recycled back to the reactor, and the ethylbenzene column separates the ethylbenzene from the bottoms.

The ethylene feed stock is produced by steam cracking of propane. Udex-grade benzene is purchased from manufacturers as the second feed material. The propane cracking-gas recovery system has been simplified considerably in that refrigeration is not required. A very clean separation is made between propylene and ethylene by absorption and stripping. The resulting total C_2 and lighter stream is then charged to the ethylbenzene feed absorber.

After seven months of operation on the original charge of the new type of catalyst, the unit is still operating at a high ethylene conversion rate. The ethylene conversion started at 98% and presently is at 90%. This reduction is due in part to increasing the unit production beyond the design capacity with only a partial catalyst charge. The drop in conversion will be compensated for in the next run by increasing the catalyst loading.



Simplified flow-diagram of ethylbenzene unit, showing the catalyst chamber.

In a typical operation on the ethylbenzene unit the charge of ethylene is 17,700 gal./day and of benzene 19,400 gal./day. Ethylbenzene products yield is 25,800 gal./day and that for bottoms, 2000 gal./day.

The composition of the ethylbenzene (purity normally 99.9+%) and bottoms products is as follows:

Typical Composition of Ethylbenzene Unit Products

	Composition, Wt. —%
Ethylbenzene	
Ethylbenzene	99.9
Other aromatics	0.1
	100.0
Bottoms	
Ethylbenzene	2.6
Diethylbenzene	67.8
Cumene	9.1
Triethylbenzene	2.7
Butylbenzene	17.8
	100.0

The ethylbenzene product when dehydrogenated and fractionated, results in a styrene having a purity of between 99.75 and 99.9%.

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SIMPLIFIED GRAPHICAL COMPUTATIONS IN LIQUID-LIQUID EXTRACTION

An extension of the McCabe-Thiele graphical method to systems hitherto unapproachable by it is illustrated by worked examples

by RUTH BLUMBERG, M.Sc., Ph.D.

THE application of solvent extraction in practice requires the determination of optimum operating conditions. Of the many methods suggested for the calculation of design data in multi-stage counter-current transfer systems, none is simpler than the conventional McCabe-Thiele graphical method of stepping off stages between operating and equilibrium lines on rectangular co-ordinates. However, whereas this method is commonly used in absorption and distillation, its analogous application to liquid-liquid extraction systems is much more limited, and it is used as a rule only in the special case of two mutually immiscible solvents,[1] where no volume changes take place in either phase flowing through the equipment and solute enters the equipment only in the feed solution.[2] The more extended application of the McCabe-Thiele procedure which has been developed and is presented here can therefore be of considerable interest.

TABLE I

Example Type	I	II	III
Number and designation of components	4, *ABCD*	4, *ABCD*	3, *ABC*
Transfer	*C* from *ABC* → *D*	*C* from *ABC* → *D*	*A* from *AB* → *C*
Solubility Relationships			
Mutually immiscible components	*A* and *D* *B* and *D*	*B* and *D*	*B* and *C*
Partially miscible components	*C* and *A*	*A* and *D* *A* and *B*	*A* and *C* *A* and *B*
Completely miscible components	*C* and *D*	*C* and *A* *C* and *D*	
Illustrative cases	*A* H_2O *B* $CaCl_2$ *C* n-BuOH *D* C_6H_6	*A* H_2O *B* $CaCl_2$ *C* HCl *D* n-BuOH	*A* H_2O *B* NaBr *C* n-BuOH
Component streams	(1) *AB* (2) *D*	*B* *D* + definite level of *A*	*B* *C*

General Considerations

The essential simplicity of the McCabe-Thiele graphical procedure lies in the fact that the operating line can be located by a material balance over the whole system. For this to be valid it is necessary that the operating line be straight, i.e., that there be a constant linear relationship between phases throughout the whole extraction system.

When the specified conditions of mutual immiscibility of solvents and constancy of volumes throughout the system apply, this requirement of a linear relationship is satisfied and that is why the McCabe-Thiele procedure has been applied in such cases in liquid-liquid extraction. However, constancy of volumes is more the exception than the rule in extraction systems. If the method is to have wider application, it is necessary, therefore, to try to modify the concept of phases flowing through the system in such a way as to obtain the necessary linear relationship. This can often be done very successfully by selecting two counter-current streams of components which can be regarded as bearing a constant weight relationship to each other within the desired range of operation. These streams need not each be a single entity, nor is it necessary that each encompass the whole of the phase flowing.

The constant weight ratio of these two selected counter-current streams of components serves to fix a straight operating line, since concentrations of the extractable component are expressed as weight ratios with respect to each of the selected constant streams. This also applies to the equilibrium line, which is presented with respect to the same component streams, concentration ratios being calculable from ordinary distribution data (in general, equilibrium lines will not be straight). Since weight relationships alone determine both equilibrium and operating lines, volume changes have no significance, and even extreme changes will not invalidate the straight-line relationship of the operating line, provided stream component selection has been appropriately made.

Dr. Blumberg *is with the Israel Mining Industries' Laboratories, Haifa, Israel.*

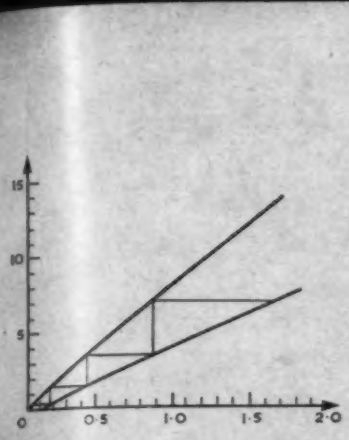

Fig. 1. Example I. Recovery of n-BuOH from aqueous $CaCl_2$ brine by extraction with C_6H_6.

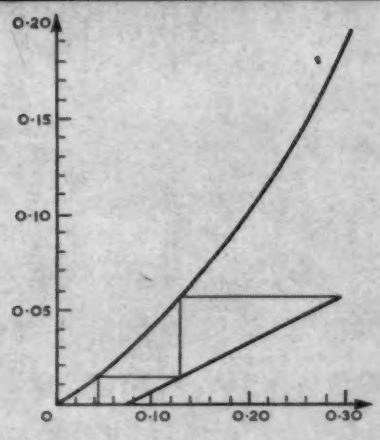

Fig. 2. Example II. Extraction of HCl from $CaCl_2$-HCl-H_2O mixture by means of n-BuOH.

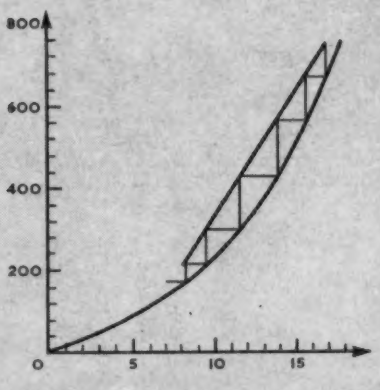

Fig. 3. Example III. Concentration of aqueous solution of NaBr by means of water transfer with n-BuOH.

EXAMPLE I

Recovery of n-BuOH from Aqueous $CaCl_2$ Brine by C_6H_6

Aqueous feed	$CaCl_2$-H_2O-n-BuOH 1.67% n-BuOH in a brine containing 266 g $CaCl_2$/l. Sp. Gr. 1.20
Solvent feed	C_6H_6 Sp. Gr. 0.88.
Experimental conditions	24 l/hr brine feed 8.2 l/hr C_6H_6
Raffinate	0.125 wt. % n-BuOH in brine
Extract	6.6 wt. % in n-BuOH in C_6H_6
Number of experimental stages ...	4
Graphical analysis	Number of stages 3-4 (Fig. 1)

EXAMPLE II

Extraction of HCl from $CaCl_2$-HCl-H_2O Mixture by Means of n-BuOH

Solvent feed	Hydrated n-BuOH containing 10% H_2O
Aqueous feed	Brine containing 318 g $CaCl_2$/l, 0.96 g H+ as HCl/l, i.e., 0.30 g H+/100 g $CaCl_2$ and saturated with n-BuOH
Aqueous raffinate	$CaCl_2$ brine containing 0.26 g H+ as HCl/l, i.e., 0.072 g H+/100 g $CaCl_2$
Feed ratios	412 weight parts n-BuOH (containing 10% H_2O) per 100 parts $CaCl_2$. No transfer of H_2O or alcohol between the two selected component streams occurs.
Experimental number of stages ...	2
Graphical number of stages	1-2 (Fig. 2)

EXAMPLE III

Concentration of NaBr Solution

Initial concentration of aqueous solution	130 g NaBr/l, i.e., 740 g H_2O/100 g NaBr Sp. Gr. 1.09
Volume of aqueous feed per 100 NaBr	770 ml
Concentrated solution	465 g NaBr/l, i.e., 190 g H_2O/100 g NaBr Sp. Gr. 1.35
Volume of concentrated solution per 100 NaBr	215 ml, i.e., a threefold volume decrease in the aqueous stream
H_2O to be removed per 100 g NaBr	500 g
Dehydrating solvent n-BuOH containing 7% H_2O	Sp. Gr. 0.82, i.e., 7.87 g H_2O/100 g n-BuOH
Hydrated alcohol to be discharged with 14.6% H_2O	i.e., 17 g H_2O/100 g alcohol
Water transfer capacity of alcohol	9.13 g H_2O/100 g alcohol
Alcohol fed per 100 g NaBr, i.e., per 840 g dilute aqueous solution ...	6000 g alc. (anhydrous), i.e., 6472 g alcohol feed
Number of stages	5-6 (Fig. 3)

Practical Selection of Passing Streams

The selection of stream components can be made in a variety of ways depending upon the system involved and the nature of the component to be transferred. A few sample cases are summarised in Table I.

In a quaternary system, *A*, *B*, *C*, *D*, as in Example I, in which *A* and *D* are mutually immiscible solvents, and *B* and *C* are solutes of which *B* is essentially insoluble in *D*, *C* is to be extracted from admixture with *A* and *B* by solvent *D*. The presence of *B* does not influence the transfer of *C*. Here *D* forms one constant stream, while *AB* or *A* alone may be regarded as the other. The recovery of n-BuOH from a $CaCl_2$ aqueous brine by extraction with C_6H_6 is a case in point, and is presented in Fig. 1.*

Another quaternary system but more complex in its solubility relationship is one given in Example II in which *B* and *C* are solutes fed to the system in a solution of *A*; the solute *B* is insoluble in *D*, whereas *C* is completely miscible with *A* and *D* and is to be extracted from the feed by means of *D*. The presence of *B* in the solution of *A* appreciably influences the transfer of *C* from *A* to *D*. Here *B* is chosen as one stream, the other being *D*, but containing a definite level of *A*. In Fig. 2 the system H_2O, $CaCl_2$, HCl, n-BuOH is given as representing this class.

Example III demonstrates the application of this method to a case in which very far-reaching volume changes occur; the system consists of a dilute solution of solute *B* in water *A*, from which the water is to be removed by means of a solvent *C* so as to leave a saturated aqueous solution of *B*; *B* is essentially insoluble in *C*. Such a situation is common in the method of water transfer by mutually immiscible solvents[3] and is given in Fig. 3 for the system H_2O, NaBr, n-BuOH. Here the solute is regarded as one stream, the solvent as the other, while water transfers from the solute to the solvent. It is possible to carry this concentration by water transfer to the stage where the solute is obtained in solid form, and still this graphical procedure remains applicable.[4]

* Examples I and II are systems encountered in variations of the process covered by B.P. 805,517.

ACKNOWLEDGMENTS

The experimental data used for verifying this method of graphical computation have been taken from unpublished reports of various research workers in the Israel Mining Industries' Laboratories. This paper is published with the permission of the Directors of Israel Mining Industries.

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APPLICATION OF THE POLYBLOC SYSTEM TO THE CONSTRUCTION OF ABSORBERS*

A new design of absorber for corrosive conditions with details of performance for absorption of hydrochloric acid

by A. J. HILLIARD

THE absorption of gas in a liquid is an essential stage in the manufacture of a variety of industrial products. The efficiency of many absorption processes is a function of the temperature of the liquid. For instance, if the process of solution liberates heat, the liquid must be adequately cooled, otherwise the rise of temperature will reduce the solubility of the gas and may temporarily convert absorption into evolution of gas. It is, therefore, generally desirable to construct the apparatus from materials of good thermal conductivity in order to facilitate the control of temperature. Many absorption processes involve the use of corrosive fluids and require equipment constructed from material which is not subject to chemical attack.

A particularly interesting material for such constructions is graphite, which is unique in its combination of high thermal conductivity with very versatile resistance to chemical attack.[1] An added advantage of graphite is that, since in normal practice it does not form solid compounds,[2] it is not subject to surface scaling which inhibits the thermal conductivity of many metals even as the result of mildly corrosive conditions (e.g., rust on iron in contact with water and air). To employ graphite to best advantage, it is necessary to construct such equipment with due regard to the mechanical and physical characteristics of the material.

Design Considerations

Design considerations for graphite were discussed in previous publications.[2, 3] The properties of graphite differ in many respects from those of the commonly used constructional metals. Unlike the latter, graphite is highly anisotropic, and its compressive strength is much better than its tensile strength. Whereas the compressive strength of good constructional graphite is of the order of 15,000 psi (105 kg/sq. cm), its tensile strength is only a fraction of that figure.

Graphite is neither malleable nor ductile. To exploit the good compressive strength of graphite, it is necessary to use it in the form of strong blocks. Structures based on tubular or such-like systems fail to exploit the good compressive strength of graphite, for they are subject to tensile stresses, caused by flexion. To fix the tubes in the header plates, cemented joints are used, and floating headers are needed to compensate for differential expansion between the graphite tube bundles and the metal shell. The limiting working pressure with tubular units is only a fraction of that permissible with graphite blocks. Any preferred orientation of the anisotropic graphite crystals is, in tubes, opposite to the direction of desired heat transfer. In drilled blocks, the two sets of heat-exchange passages can be placed so as to exploit anisotropic orientation of the crystals for best thermal conductivity between the fluids.[1]

Equipment based on a monoblock system has been disclosed by Stancliffe[4, 5] and others,[6] and takes advantage of the good compressive strength of the material. However, Stancliffe developed this system primarily for use with metals. Because it is difficult to drill long passages through a solid block, he suggested that the heat-exchange passages should be formed either by the lost core method of casting or by using metal plates, grooved on both sides and sweated together in piles to form blocks.

Graphite cannot be cast or assembled by welding or sweating. Application of the Stancliffe system to graphite construction involves, therefore, either the drilling of long passages through a solid block, which is associated with various difficulties, or the use of grooved plates which are cemented together to form heat-exchange blocks.

Cements which are suitable for use with graphite are substantially limited to a small range of resin-based materials. They may introduce problems of differential expansion, embrittlement of the cement joints through the combined effect of temperature and certain heat-exchange fluids, and reduced versatility. Equipment which is rigidly cemented together is less versatile than an assemblage of detachable units.

These are some of the reasons why it is preferable not to apply to constructions in graphite principles of design suitable for metals. The advantages of basing the design of graphite equipment on the characteristics of the material alone, without reference to prior art, were explained in previous publications[1–3] and they were exemplified by the description of a heat exchanger, the Polybloc.[7–12] It will be shown in subsequent paragraphs how the Polybloc system can be adapted for gaseous absorption.

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* This paper was presented before the Swedish Royal Technological Institute, Stockholm, on October 19, 1959.

Process Considerations

The efficiency of absorption is usually determined by the following principal factors:

(1) "effective" area of the absorbing liquid, which should be as large as possible;

(2) flow characteristics of the gas or vapour to be absorbed. Absorption efficiency is generally improved if the gas to be absorbed is turbulent. Turbulence of the gas stream should be obtained with the least possible loss of pressure; and

(3) many absorption processes are accompanied by the liberation or, less frequently, the absorption of heat, and such heat must be respectively evacuated or supplied.

Existing Practice

One method of construction employs towers which are filled with suitable packings. A wide variety of such packing units exists; e.g., Raschig rings, Lessing rings, Berl saddles, Star packings, etc. They are usually made from carbon, ceramics or other suitable materials. The object of these packings is to provide the largest possible contact area for the reacting fluids. However, because this type produces a "non-geometrical" packing, the actual contact area may be very much smaller than the theoretical area of the packing. This may be due to a variety of reasons, including short-circuiting and lensing of the absorbing liquid. The pressure drop of the gas through such non-geometrical packings is generally high.

Considerable improvements are possible if geometrical packing means are substituted for the aforesaid non-geometrical ones. Geometrical tower packings can be made from carbon bars cemented together in the form of grids, which are stacked in the absorption tower. These grids can be arranged to ensure substantially complete wetting of all their surfaces, and they avoid the hazards associated with lensing and short-circuiting of fluids.

On the other hand, these grid packings are more costly to produce and more difficult to transport to the user's site. Cemented joints are required to hold individual grids together, and it has been explained previously that it is desirable to avoid the use of cemented joints in carbon constructions. Another problem is that absorption towers are usually cylindrical, and it is not easy to make circular grid packings to fit existing towers.

A serious problem associated with all tower systems arises if the fluids have to be cooled or heated during absorption, because this necessitates the interspacing of heat-exchange elements between layers of packings, which may be cumbersome.

One of the most important industrial applications for absorption equipment is in the manufacture of hydrochloric acid. Because of the large quantities of heat which are evolved when hydrogen chloride is dissolved in water, it is necessary to provide very efficient cooling in order to avoid excessive vapour pressure in the reacting fluids. One way of doing this is to use a falling-film absorber, employing vertical heat exchangers, usually made from graphite. The absorbing liquid (water or dilute HCl) is allowed to flow down through the process passages in parallel or in counter-current with the gas. A suitable cooling fluid (usually water) is circulated through service passages. With this arrangement, it is somewhat difficult to ensure a continuous film of the absorbent. If, for any reason, the film in any passage is broken, there is no means of regenerating it and the liquid then flows over the remaining distance of the passage in rivulets. This results in loss of "effective" absorption area and corresponding loss of efficiency. Moreover, the preferred direction of the hydrogen chloride molecules is parallel to the absorbing film.

It is the object of this paper to describe a system which avoids the short-comings of existing methods both from the aspects of process efficiency and construction. For reasons which were previously explained, this unit is preferably constructed from graphite, and, in order to exploit the characteristics of this material to the best advantage, is based upon the Polybloc system.

The Polybloc Absorber[13]

As in the case of the Polybloc heat exchanger, the basic element of the absorber is a cylindrical graphite block provided with an axial hole (o) (Fig. 1). The radial passages (p), which connect the central hole (o) with the outer periphery of the block, are similar to those of other Polybloc models. Likewise, the block is provided with peripheral gasket grooves (r) and (s) at each end, and a slightly hollowed space between these grooves to produce turbulence chambers in the assembly.

The axial passages of the absorber block differ from those of the heat-exchange block by being trumpet-shaped. It will be noted from Figs. 1, 2 and 3 that the line where the parallel and conical parts of the axial passages meet is in the form of a ridge (g). The upper end of the parallel section of each axial hole is provided with a lip (d) and the upper side of each block is provided with concentric grooves (m) which extend over the whole width of the block between the gasket grooves. These blocks are then assembled in the form of a column, with gaskets between the blocks, in exactly the same way as are Polybloc heat exchangers (Fig. 3).

As in the latter, graphite header blocks and strong metal header plates are provided at the two ends of the column, which is held together under compression alone by spring-loaded external tie bars. The outer metal shell is again identical and interchangeable with that of any corresponding Polybloc heat exchanger. In addition, members which act as distributors for the various fluids are fitted to the ends of the assembled unit.

System of Absorption

This will be illustrated by an example assuming the counter-current absorption of hydrogen chloride in water to produce concentrated HCl acid.

The absorbent, e.g., water, enters at the top (a) of the assembly. It flows down through the orifice (b) into the feed channels (c) of the upper header. From there, it is fed to the upper surface of the first absorber block, and is distributed by the concentric grooves (m) to all the axial passages of the first block. The absorbing water then runs into the reservoir formed by the lip (d), which is provided at the upper end of each axial channel. From there it overflows as an even film, first down the parallel section of the axial passages, and then down the conical section. Thereafter, the liquid descends to the upper surface of the second block, where it is redistributed by the concentric grooves (m) to the lips (d) at the upper ends of the axial passages of the second block, and the flow continues downwards until the concentrated acid is discharged at the end of the column through the lower header (e) and the channel (f) in the lower attachment. Since the lower end of each axial channel is of larger diameter than the upper end of the parallel section of the hole below it, and since all axial passages are aligned, no fluid can pass through the unit without being redistributed at each block interface. The absorbing liquid film is thus continually regenerated.

A particularly important function is fulfilled by the ridge (g) between the conical and parallel sections of the passages. If the supply of absorbent has to be reduced to a quantity which is less than that required for a continuous film over all the absorbing area, the film will become shorter, but will remain substantially uniform below and

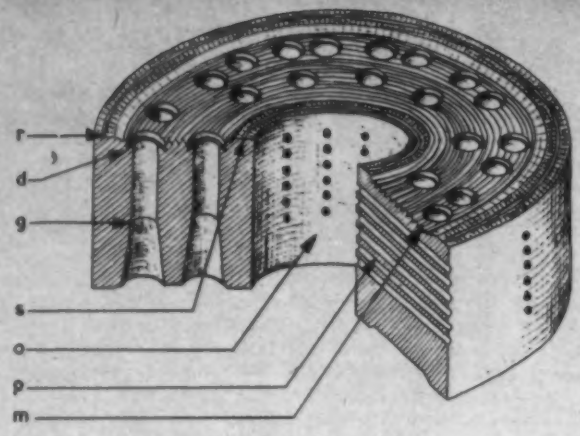

FIG. 1

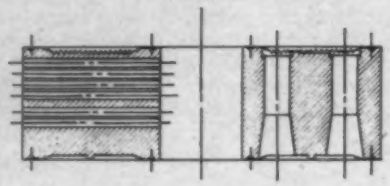

FIG. 2

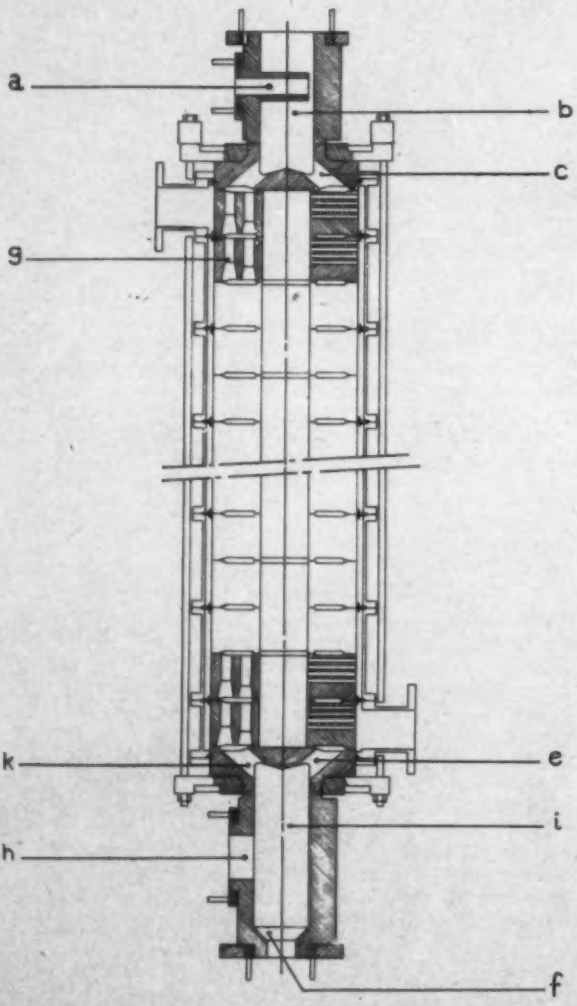

FIG. 3

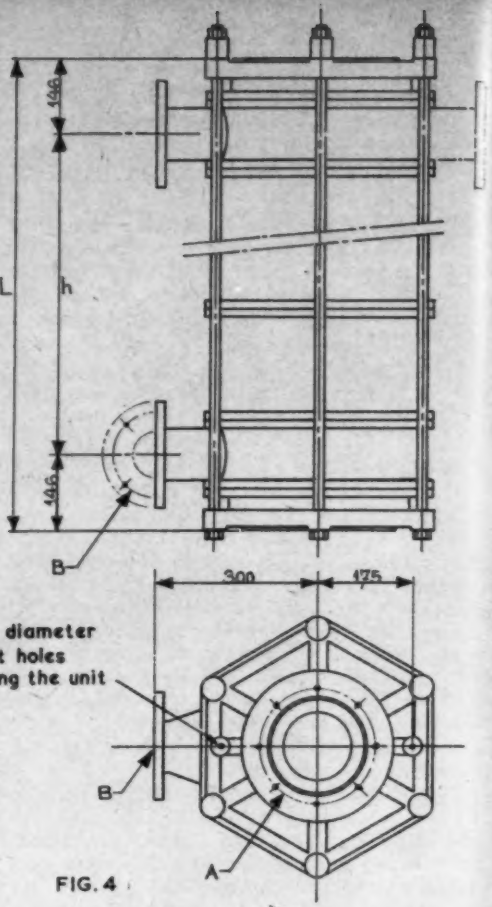

FIG. 4

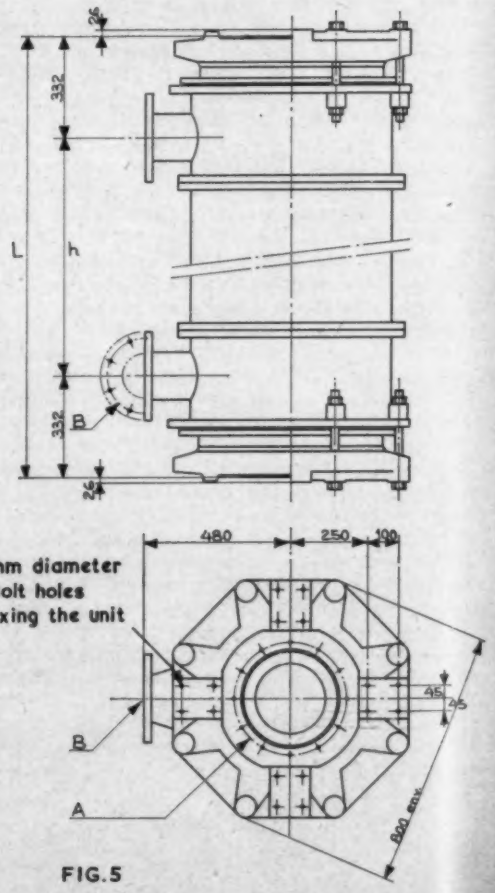

FIG. 5

Fig. 1. Cut-away view of absorber block showing arrangement of passages. (d) Lips, acting as reservoirs, at upper ends of absorption passages. (g) Ridges, between conical and parallel sections of absorption passages. (m) Concentric grooves on upper surface of block to ensure uniform distribution of liquid to all absorption passages. (o) Central axial hole through block. (p) Radial passages for service fluid (e.g., cooling water). (r) Outer peripheral gasket groove. (s) Inner peripheral gasket groove.

Fig. 2: Cross-section of absorber block.

Fig. 3: Assembly sketch of absorber (GMA Model). (a) Feed pipe distributor for absorbing liquid (e.g., water, dilute HCl acid, etc.). (b) Vertical hole through upper end attachment, for feed of absorbing liquid and discharge of inert gases. (c) Distributing channels through upper graphite header block. (e) Lower graphite header block. (f) Discharge channel (e.g., for concentrated HCl acid) through lower end attachment. (g) Absorber blocks. (h) Gas feed orifice in lower end attachment. (i) Vertical hole through lower end attachment for feed of gas and discharge of concentrated acid. (k) Distributing channels through lower graphite header block.

NUMBER OF BLOCKS	L mm approximately	h mm approximately
2	423	131
4	635	343
6	847	555
8	1059	767
10	1271	979
12	1483	1191
14	1695	1403
16	1907	1615
18	2119	1827
20	2331	2039

A. Entrance or exit pipe for the process fluid :
inner diameter : 125 mm
outer diameter of the graphite part : 175 mm
8 bolt holes of 10 mm diameter on a circle of 210 mm diameter

B. Flanged lateral entrance or exit pipe :
inner diameter : 90 mm
4 bolt holes of 18 mm diameter each on a circle of 160 mm diameter

Fig. 4: Outer dimensions and design data of shell of standard absorber (Model GMA).

NUMBER OF BLOCKS	L mm approximately	h mm approximately
2	966	302
3	1208	544
4	1450	786
5	1692	1028
6	1934	1270
7	2176	1512
8	2418	1754
9	2660	1996
10	2902	2238
11	3144	2480
12	3386	2722
13	3628	2964
14	3870	3206

A. Entrance or exit pipe for the process fluid :
inner diameter : 225 mm
outer diameter of the graphite part : 315 mm
14 bolt holes of 14 mm diameter on a circle of 350 mm diameter

B. Flanged lateral entrance or exit pipe inner diameter : 150 mm
8 bolt holes of 22 mm diameter each on a circle of 240 mm diameter

Fig. 5: Outer dimensions and design data of shell of large absorber (Model SMA).

above the ridge (g). The arrangement therefore takes advantage of the effect of surface tension in retaining a uniform film extending below and above the ridge, even if the flow of liquid falls below the optimum. Experience has shown that a uniform film can thus be maintained with variations of flow in the ratio of 1 to 4½.

If, for example, heat-exchange blocks of 10 cm thickness are used, then the provision of the ridge (g) between the conical and parallel part of the process passages ensures that the film is regenerated every 5 cm during its entire flow through the apparatus.[14]

The hydrogen chloride enters through the orifice (h) in the lower attachment and flows up through the channel (i) of the latter, through the distributing channels (k) of the lower header into the conical section of the axial passages of the last block. The upwardly decreasing section of these channels compresses the gas and increases its velocity. On entering the first turbulence chamber, the compression of the gas is suddenly released, and this process is repeated in each block. The effect can be likened to that of venturi or jet nozzles. Moreover, the partially conical section of the passages results in a directional orientation of gas flow with respect to the liquid film, which is preferable to that of arrangements where the preferred direction of gas flow is parallel to that of the film (e.g., in parallel-sided falling film absorbers).

The radial passages (p) through which the cooling fluid circulates are spaced between, and closely adjacent to, the axial absorption passages.

As in all Polybloc arrangements, the ratio of the length to the diameter of these passages is very small, and advantage is taken of the "end effect" to induce turbulent fluid flow. Any preferred orientation of the anisotropic graphite crystals is with their long (conduction) axes at right angles to the bore of the two sets of passages. Highest heat-transfer efficiency is therefore ensured, and the absorbing film can be kept at any desired temperature within the limits of the available cooling fluid. The arrangement is consistent with very favourable conditions of pressure drop, no energy being wasted by the movement of gas over unwetted areas.

Because of the high efficiency, comparatively small absorber units are adequate for duties for which much larger arrangements were previously required. It is a particular advantage that this unit avoids the use of a circulating pump, which may be necessary with other methods.

Construction

The arrangement possesses a number of constructional and mechanical advantages.[3] It is assembled from standard elements, thus permitting the easy adjustment of heat-transfer (absorption) area by the use of the requisite number of blocks. The contour and outer dimensions of the absorber blocks are identical with those of corresponding Polybloc heat-exchange blocks and interchangeable with the latter. Identical shells can be used for both types. The system is assembled under compression only, and takes advantage of the best mechanical property of graphite (compressive strength). The robustness compares, therefore, with that of equipment constructed from metal.

The process fluids are in contact only with impermeable graphite and with chemically resistant gaskets. There are no cemented joints anywhere in the absorber. Fluid-tightness is ensured by the provision of suitable gaskets between blocks. The blocks are cylindrical so as to permit the use of circular gaskets (O-rings), because this shape, more effectively than any other, ensures fluid-tightness. A wide choice of suitable gasket materials is available, ranging from synthetic rubber to PTFE (Teflon or Fluon). The chemical inertness of the latter compares with that of the

graphite of the blocks.

All passages, including those for the service fluid (cooling water), are very short with respect to their diameter. The turbulent flow of the cooling fluid, which is induced by the small length/diameter ratio of the passages, produces not only high heat-exchange coefficients, but has also marked scale-inhibiting and antifouling effects.

The assembly is very simple, and it is a particular advantage that increased production can be obtained simply by adding *in situ* the required number of absorber blocks.

Unit Sizes

These absorbers are, at present, made in two standard sizes. The smaller (called GMA) corresponds to the Polybloc Standard Model heat exchanger GM. Figs. 1, 2 and 3, as well as the respective text, refer to the GMA model. Fig. 4 indicates the outer dimensions of this model. The larger (called SMA) corresponds to the Polybloc Super Model heat exchanger, SM, and its outer dimensions are indicated in Fig. 5.

A maximum number of 20 blocks can be accommodated in a single GMA unit and up to 15 blocks in an SMA. The absorption area of an SMA block is approximately 4 sq. m. It is therefore possible to accommodate absorption areas of up to 60 sq. m. (645 sq. ft) in a single apparatus. The limiting quantities of fluids depend on the process conditions. As a rough indication of the order of magnitude, the following quantities of fluids are indicated in the case of the manufacture of 33% hydrochloric acid.

	Standard Model GMA	*Super Model SMA*
Maximum total quantity of gas entering the absorber	500,000 l./hr	1½ million l./hr
Minimum quantity of absorbing liquid	150 l./hr	400 l./hr
Maximum quantity of absorbing liquid	2500 l./hr	7500 l./hr
Cooling water required (assuming entrance temperature of about 18°)	20 times the weight of the HCl gas which is to be totally absorbed to produce HCl acid of 33% concentration.	

The example of 33% was selected because this is a usual concentration of commercial HCl acid. It is evident that the system is suitable for the production of any concentration which may be desired, and the upper limit is substantially a function of temperature conditions and stability of the end product after discharge from the absorber. The effect of dilution of the HCl gas to be absorbed is in line with general experience. The higher the concentration of HCl gas, the smaller will be the absorption area required for a given duty and vice versa.

Work is in hand to establish simple formulæ which will permit rapid estimation of assemblies required to satisfy various process duties. It is hoped to discuss these in a subsequent publication.

From present indications it appears that under favourable process conditions the maximum production of, say, 33% HCl acid may be expected to be approximately 40 tons per 24-hour day with the Standard Model GMA and about 150 tons for the Super Model SMA. More specific data on this aspect could be discussed in the proposed subsequent publication, and it is also hoped to include examples of longer range industrial experience.

Industrial Performance

The Polybloc absorber is a comparatively recent development. The availability of industrial performance data with the absorber is therefore, at present, still limited. However, the following description exemplifies the performance of a unit which was installed at the beginning of 1958.

In this plant 10 tons of 33% hydrochloric acid per day are normally produced. The absorber used comprises only six blocks. It is 85 cm high (exclusive of end attachments for feed and discharge of fluids respectively) and the outer diameter (floor space occupied by the unit) is 48 cm. The following data are illustrative of the process and performance conditions of this installation.

The absorbing water enters the unit at a temperature of 5.5°C. The hydrogen chloride to be absorbed contains 4% of inert gases. Cooling water at a temperature of 3.5°C enters the unit at the rate of 5½ tons/hr and leaves at a temperature of 11.5°C. The unit has been found to perform satisfactorily over a wide range of output, namely from 3 to 14 tons of acid per day. This shows not only that all surfaces are fully utilised for maximum performance, but it illustrates also the great versatility which is possible with a given installation with respect to variation in daily production.

This GMA-type absorber of six blocks can, if required, be increased to a maximum of 20 blocks in a single apparatus, so as to yield a correspondingly increased output. It should be pointed out that the aforesaid unit, which was a prototype, employed blocks having only 24 axial channels each. The number of axial channels in GMA blocks was subsequently increased to 40 in order to improve the absorption area and overall efficiency. The figures in the above example appear, therefore, to be subject to a factor of 5/3 if applied to GMA blocks of current manufacture.

For convenience of illustration, the previous description and example was based on the manufacture of hydrochloric acid. The system is, of course, applicable to many other absorption processes.

For an exact evaluation of the economics it will be necessary to await details from a number of industrial installations, measured over long periods. However, indications to date are highly encouraging. Because of the efficiency of the system, it is possible to use comparatively small absorbers for duties for which much larger units were previously required. The easy control of all aspects of performance simplifies the determination of process data, and because this permits more exact dosing of fluid quantities it should result in considerable savings in running costs. It is also fairly safe to predict that in the majority of cases the capital cost of these units will, because of their efficiency, be considerably less than that of alternative larger equipment necessary for comparable performance.

Acknowledgement

The development and realisation of the system described in the above paper were carried out under the direction of Mr. J. Clause, the technical director of Société Le Carbone-Lorraine. His solutions of many practical problems were invaluable and the author is glad of this opportunity of recording his great appreciation.

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Note: References 7 to 11 and 13 cite only the British numbers of the respective Polybloc patents. It should be noted that corresponding Convention Patents have been granted in other countries where such Patents were applied for. All these Patents cover the constructional features generally and are not limited to any specific material.

66.074.1

COUNTER-CURRENT GAS AND LIQUOR FLOW THROUGH BEDS OF RANDOM-PACKED RASCHIG RINGS

The influence of packing size upon the distribution of flow of gas and liquid phases

by F. R. WHITT, M.Sc., A.M.I.Chem.E., F.R.I.C.

THE literature,[1, 4 and 9] published recently, shows that the total wetted surface associated with irrigated beds of random-packed Raschig rings is, on occasion, several times larger than the estimated wetted surface, effective from the point of view of mass transfer. Mayo, *et al.*[5] suggested that 10% of the wetted surfaces of Raschig rings may consist of stagnant liquid. It would appear that some other explanation than the existence of stagnant liquor is necessary to explain recently discovered facts. Uneven distribution of gas and liquor flows, as between the outsides and insides of the rings, could tend to produce inefficiency, from the point of view of mass transfer, of wetted surfaces. Hence it was thought worth while examining data in the literature to see if there was experimental evidence suggesting that gas and liquor flows did not follow the same path.

Examination of the Literature

(a) Gas Flow (Pressure-drop Experiments with Hollow and Filled Raschig Rings)

Examination of Fig. 10 of Reference 7 shows that the "hollowness" property of Raschig rings, with respect to gas flow, decreases as the rings get smaller. The change of Ap factor value is several-fold, whereas the free space fraction change for the rings in question is only 1.4-fold. This fact suggests that the smaller the rings, the greater the tendency to resemble solid particles in their resistance to gas flow, the gas passing over the rings tending to flow towards the ouside.

It appeared reasonable to try to obtain a measure of the distribution of gas flow, as between the outsides and insides of rings, by comparing the pressure drops obtained with hollow rings with those associated with filled rings of the same size. The pressure-drop effects, due to sizes and numbers of constrictions in the free spaces, on the outside of the filled rings could be assumed to closely resemble those of the outsides only of the hollow Raschig rings.

Relevant curves from the work of Hands *et al.*[7] are reproduced on the composite plot (Fig. 1). Comparison of the $\triangle p$ values, for equal G/θ values, show that on an average for dry rings,

Symbols Used

Ap = correction for hollow packing effect;
$\triangle p$ = pressure drop, in. of water column/ft of packing;
G = gas flow-rate, lb./(hr) (sq. ft), empty column;
L = liquor flow-rate, lb./(hr) (sq. ft), empty column; and
θ = correction factor for change in gas density or $\sqrt{\left(\frac{\text{density of gas lb./cu. ft}}{\text{density of air at 20°C and 760 mm Hg or 0.075 lb./cu. ft}}\right)}$

$$\triangle p \text{ filled rings}/\triangle p \text{ hollow rings} = 1.32 \text{ for } \tfrac{9}{16}\text{-in. rings} = 1.75 \text{ for } 1\tfrac{1}{16}\text{-in. rings} \quad \ldots . (1)$$

The effect of liquor flow, up to 400 lb./(hr) (sq. ft) empty column, on the above ratios appeared to increase the ratios by about 12%. In the case of wetted and drained rings, the ratios were numerically indistinguishable from those given above.

Gas flow through beds of random-packed Raschig rings obeys, approximately, the law for orifice flow, i.e., the gas flow-rate is proportional to the square root of the pressure loss. In the case of the filled rings, all the air flows on the outsides of the rings and at a greater individual rate for a given G/θ value (measured on the empty column area) than over the outsides of hollow rings of the same diameter, because in the latter case some flow can pass through the interiors of the rings. The square roots of the values given in Equation (1) above give the increased gas flow-rates over the outsides of rings due to the blocking of the interior passages and diversion of gas flow. Hence, assuming that the physical conditions on the outsides of the filled and hollow rings are the same,

Ratio of gas flow-rate over insides and outsides of rings to flow-rate over outsides only

$$= \sqrt{1.32} \text{ or } 1.15 \text{ for } \tfrac{9}{16}\text{-in. rings} = \sqrt{1.75} \text{ or } 1.33 \text{ for } 1\tfrac{1}{16}\text{-in. rings} \quad \ldots . (2)$$

Hence it can be concluded that with hollow rings 0.15/

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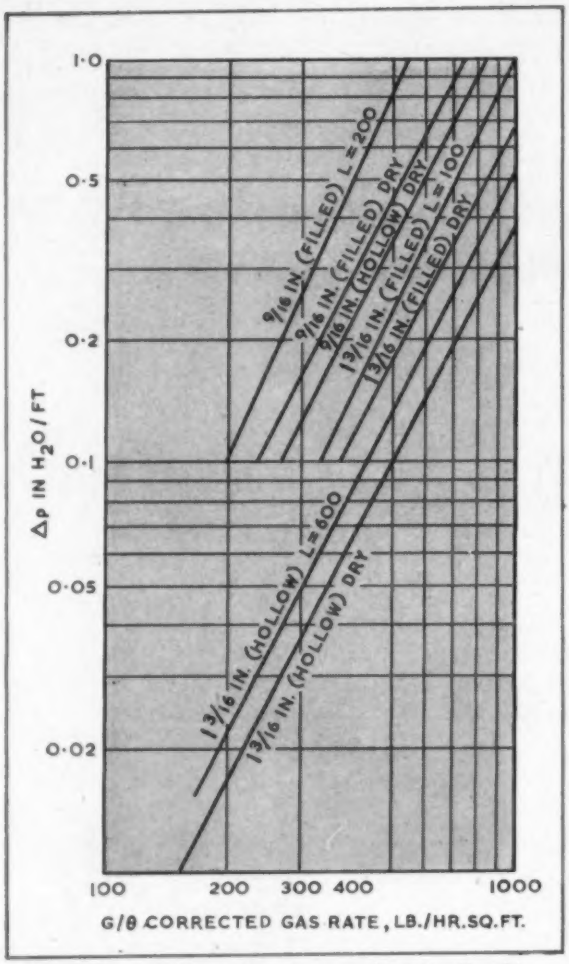

Fig. 1. Pressure drop data, $\frac{9}{16}$-in. and $1\frac{3}{16}$-in. Raschig rings (filled, hollow, dry and irrigated).

1.15, or 0.13, and 0.33/1.33, or 0.25, are relative fractions of the total gas that pass through the interiors only of $\frac{9}{16}$-in. and $1\frac{3}{16}$-in. diam. Raschig rings.

The above two results are plotted on Fig. 2 as curve A, showing the relation between the fraction of gas flowing through the interiors of rings and the ring diameter. In order to increase the usefulness of curve A, it seemed reasonable to extrapolate in the direction of zero at ring diam. $\frac{1}{16}$ in. (i.e., the point at which a ring, with a wall thickness of $\frac{1}{32}$ in., becomes a solid cylinder), and towards unity for rings of diameter approaching 6 in. (the diameter of the column used in the work described in Reference 7).

Morcom[6] summarised the literature concerning pressure-drop experiments on gas flow through beds of solid particles including some cylindrical particles. It was thought that from data presented it might be possible to calculate extra points to use with curve A of Fig. 2. It was found, however, that no data on particles of a cylindrical shape similar to Raschig rings, or of a large size such as $\frac{1}{2}$ to 2 in. diam., had been recorded, so that reliance for curve A had to be placed on data quoted previously from Reference 7. It appears from the general trend of curve A (Fig. 2) that the gas flow distribution is such that the inner free space of the rings is deprived of gas flow.

It is worth noting that when the walls of Raschig rings are perforated (Pall ring) the pressure drop for a given gas flow, measured on an empty column basis, is decreased. This suggests that the perforations provide inlets and exits so that the inner free spaces receive a greater proportion of gas flow than with normal rings. Performance data concerning Pall rings are given by Pfannmuller,[8] who states that dry Pall rings of 50 mm. diam. produce only 0.69 of the pressure drop associated with Raschig rings of 50 mm diam. under the same circumstances.

Inspection of curve A (Fig. 2) shows that with 50-mm Raschig rings the gas flow distribution is 0.6 outer flow to 0.4 inner flow. It could be assumed that if equal distribution of flow could be arranged to take place, i.e., 0.5 to 0.5 ratio of flows, the pressure drop should be reduced in the ratio $(0.5/0.6)^2$ or 0.7. This ratio is close to the 0.69 mentioned above and suggests that with Pall rings, of 50 mm diam., equal distribution of gas flow may be achieved, a proposal supported also by the superior mass transfer performance[8] of Pall rings compared with Raschig rings.

The packing and dimensional characteristics of the Raschig rings associated with the work described in Reference 7 are tabulated in Table IV. Additional information concerning the distribution of the free space fractions as between the insides and the outsides of the rings is also given. The data were calculated from the ring dimensions, experimentally determined total free space fraction and the number of rings per cu. ft of column. Fig. 3 is a plot of these data along with other information deduced from data given in a manufacturer's catalogue. The curve trend shows that as the ring size decreases so does the ratio of the inner free space to the outer free space. This packing characteristic of Raschig rings may be, in some way, the cause of the relative gas flow through the interiors decreasing as the ring size decreases. It will be noted, however, that the ratio of the surface areas of the insides and outsides of random-packed Raschig rings varies but little with the size of the ring (see Table IV).

(b) Liquor Flow (Pressure-drop Experiments with Hollow and Filled Rings)

The plots of Reference 7 give pressure drop versus gas flow-rates for irrigated as well as dry hollow and filled Raschig rings. Typical curves are given on Fig. 1 to show the general numerical values. It was thought reasonable to compare results obtained with the two types of ring to obtain some idea of the proportion of liquor flow between the inner and outer free spaces of the hollow rings under counter-current gas/liquor flow conditions.

Taking as a standard the $L = 200$ pressure-drop curve of Fig. 21 of Reference 7 (see also Fig. 1), the pressure drop values for $\frac{9}{16}$-in. filled rings at various G/θ values were recorded. The plot (Fig. 2) of Reference 7 (hollow $\frac{9}{16}$-in. rings) was then examined and the liquor rates for G/θ values (1.15-fold) at the same pressure drops determined. It appeared that, with little variation over a three-fold range of G/θ values, the liquor rates necessary to give the same pressure-drop values were, on an average, 450 lb./(hr) (sq. ft). Thus it could be deduced that in the case of the hollow rings the inner liquor flow was 450−200, or 250 lb./(hr) (sq. ft), compared with the outer flow of 200 lb./(hr) (sq. ft), i.e., a ratio of inner to total flow of 0.56. The plots for filled and hollow $1\frac{3}{16}$-in. rings (Figs. 22 and 4 of Reference 7) were likewise examined and compared. The conclusion reached was that the ratio of the inner liquor flow to the total flow was 0.84. These deductions are recorded in Table I and plotted as curve B on Fig. 2. Extrapolation of this curve towards zero at ring diam. $\frac{1}{16}$ in. seemed reasonable.

It appears that liquor flowing counter-currently to gas through beds of random-packed Raschig rings proportions in such a way that the outer surfaces tend to be starved of

TABLE I—Liquor Distribution between Inner and Outer Surfaces of Raschig Rings (G/θ and Liquor Flow-rates, lb./(hr) (sq. ft.). Empty Column)

	Ring size (in.)															
	$\frac{3}{16}$ Filled				$\frac{3}{16}$ Hollow				$1\frac{1}{16}$ Filled				$1\frac{1}{16}$ Hollow			
	G/θ				G/θ				G/θ				G/θ			
	500	400	300	200	575	460	345	230	800	600	500	330	1070	800	665	442
Δp in. H_2O/ft.	0.83	0.49	0.25	0.1	0.83	0.49	0.25	0.1	0.64	0.35	0.235	0.1	0.64	0.35	0.235	0.1
Liquor flow (outer)	200				500	500	400	400	100				400	1000	1000	600
,, ,, (total)					450 av.								750 av.			
,, ,, (inner)					450 − 200 = 250								750 − 100 = 650			
Liquor flow (inner) / Liquor flow (total)					0.56								0.84			

TABLE II—Gas and Liquor Flow Distribution between Inner and Outer Surfaces of Raschig Rings (% of Total Flows for $\frac{1}{2}$ to 2 in. diam. Rings)

	Inner surfaces	*Outer surfaces*
Gas flow	11 to 40	89 to 60
Liquor flow	50 to 95	50 to 5

liquor as the ring size is increased.

A summary of both gas and liquor flow proportions is given in Table II. It appears that with the smaller rings the inner wetted surfaces should tend towards ineffectiveness, from the point of view of mass transfer, because of lack of gas flow. Simultaneous gas and liquor flow over the outer surfaces should, however, render these surfaces effective. With the larger rings, the reverse situation exists, the inner surfaces receiving simultaneous flows of gas and liquor and the outer surfaces are starved of liquor flow.

(c) *Mass Transfer (Gas and Liquor Flowing Countercurrently through Hollow Rings)*

Figs. 1, 2 and 3 as given by Davidson[3] and Fig. 1 as given by Whitt[4] present data concerning, for mass transfer purposes, the effective surfaces and total wetted surfaces of Raschig rings. From this information the ratios of effective to total wetted surfaces for rings $\frac{1}{8}$ to $1\frac{1}{2}$ in. diam. were determined, assuming a liquor flow-rate of 1000 lb./(hr) (sq. ft) empty column. The determination results (see Table III) were plotted on Fig. 2 as curve C. (It appeared that liquor rates (2-3000 lb./(hr) (sq. ft)), had only a very small effect upon the values of the ratios; hence only one curve was plotted.) The trend of curve C shows that the ratio of the effective to total wetted surface decreases with a decrease of ring size. The phenomenon could have its origin in the separation of gas and liquor flows as described in the preceding paragraphs.

Table III shows that, for a given liquor flow rate, Raschig rings of 1 in. diam. have the highest effective wetted surface per cu. ft. This fact is supported by data given as Fig. 3 of Reference 4. It is interesting to note that curves A and B, of Fig. 2 in this paper, show that with 1-in. diam. rings the inner gas flow is 0.22 of the total flow and the inner liquor flow 0.78 of the total liquor flow. The outside flows are the symmetrical reverse; thus neither inner nor outer surfaces are starved of simultaneous gas/liquor flow (as are $\frac{1}{2}$ in. and 2 in. diam. rings, see Table II); also an approximate estimate of the effectiveness of the wetted surface could be made as 0.22/0.5 or 0.44. This resembles reasonably well the 0.5 ratio for the effective to total wetted surface given for 1 in. diam. rings in Table III.

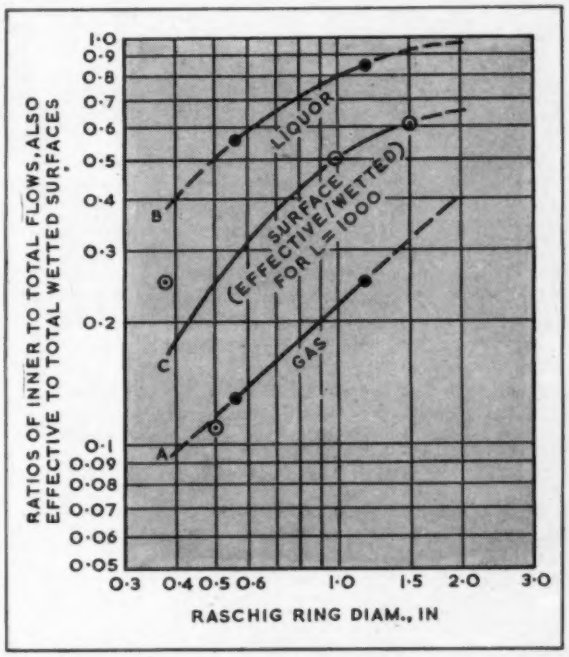

Fig. 2. Ratios of inner to total flows, also effective to total wetted surfaces (for $L = 1000$).

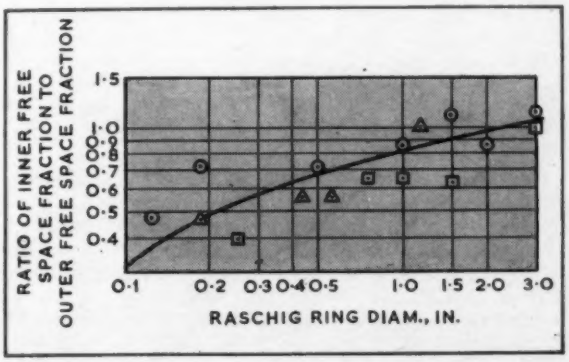

Fig. 3. Ratio of inner free space fraction to outer free space fraction v. ring diameter. Triangles refer to Table IV, squares and circles to data from manufacturer's catalogue.

TABLE III—Effective and Total Wetted Surfaces of irrigated Raschig rings (References 3 and 4)

		$L = 1000$			$L = 2000$			$L = 3000$		
		Wetted surfaces (sq. ft.)			Wetted surfaces (sq. ft)			Wetted surfaces (sq. ft)		
Ref.	Ring Size (in.)	Effective	Total	Ratio	Effective	Total	Ratio	Effective	Total	Ratio
4	$\frac{3}{8}$	8.3	31	0.26	9.5	51	0.18	10	70	0.14
3	$\frac{1}{2}$	8.0	75	0.11	10	83	0.12	11	89	0.11
3	1	13	26	0.5	17	34	0.5	20	37	0.57
3	$1\frac{1}{2}$	11	18	0.6	16	21	0.76	19	24	0.7

TABLE IV—Properties of Raschig Rings as used in Experiments (Reference 7)

Dimensions (in.)	Material	No. of Rings per cu. ft	Total Free Space Fraction (Experimental)	(A) Free Space F (Outer) (Calculated)	(B) Free Space F (Inner) (Calculated)	$\frac{B}{A}$	Total Surface (sq.ft/cu.ft)	Ratio of: Inner Surface / Outer Surface
$\frac{1}{16} \times \frac{1}{16} \times \frac{1}{16}$	Glass	134,145	0.57	0.39	0.18	0.47	173	0.67
$\frac{1}{16} \times \frac{1}{16} \times \frac{1}{16}$	Carbon	12,280	0.71	0.454	0.256	0.57	100	0.71
$\frac{1}{16} \times \frac{1}{16} \times \frac{1}{16}$	Carbon	6,462	0.63	0.4	0.23	0.57	90.3	0.67
$1\frac{1}{16} \times 1\frac{1}{16} \times \frac{1}{16}$	Carbon	759	0.8	0.39	0.41	1.01	80	0.68
$\frac{1}{16} \times \frac{1}{16}$ (Filled)	Carbon	6,868	0.4	0.4 (Exp.)	—	—	71	—
$1\frac{1}{16} \times 1\frac{1}{16}$ (Filled)	Carbon	718	0.47	0.47 (Exp.)	—	—	66	—

Conclusion

Experimental pressure-drop results, obtained from passing counter-current air and water through beds of random-packed Raschig rings in a 6 in. diam. tower at flows of up to 1000 lb./(hr) (sq. ft), i.e., below flooding conditions, suggest, with some extrapolation of results, that for rings $\frac{1}{2}$ to 2 in. diam.:

(1) The gas flow is almost completely on the outsides of the rings of small diam. ($\frac{1}{2}$ in.). Equal flow distribution, with the insides receiving as much as the outsides, probably occurs with large rings of over 2 in. diam.

(2) The liquor flow distributes in equal proportions over the outsides and insides of rings of small diam. ($\frac{1}{2}$ in.), but flows almost completely in the insides of large rings of over 2 in. diam.

(3) The tendency towards the separation of gas and liquor flow is such that, for $\frac{1}{2}$ to 2 in. diam. rings, almost complete lack of either gas or liquor flow over half the total ring surface could occur. This could be assumed to render half the total ring surface ineffective from the point of view of mass transfer.

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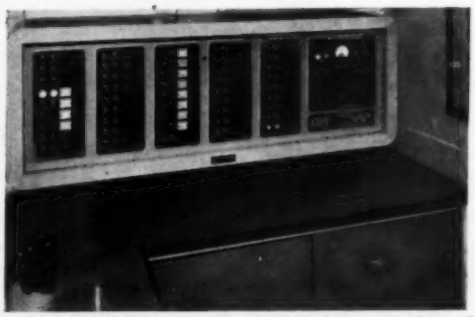
Hoover's New Fire-Detection System

OUTBREAKS of fire are detected by the breaking of a battery-fed electrical circuit in a new system which can be linked to any desired alarm or control device. A current of 20 mA is fed through a series of fusible links set in the ceilings of the rooms and corridors to be protected. Alternatively, bimetallic rate of rise detectors or soldered links may be used as the heat-sensitive elements. Signals are indicated in the central fire control office. Breaking of the circuit causes operation of relays connected to alarms and lights.

The system is designed and installed by Sound Diffusion (Autothermatic) Ltd. of Sussex. Each section of the fire-detection network is equipped with a telephone utilising the same wiring system, so that a report can be sent from the scene back to central control. As installed at the Hoover factory, Perivale, Middlesex, the detection equipment is designed to send a pre-recorded message to the Middlesex Fire Brigade if required.

Apart from the loud-speaker controls, alarm bells and detectors, all equipment associated with the system is housed in one compact cabinet, situated in a central control room. This cabinet contains a panel bearing the names of each factory section with appropriate duplicated red lights to denote fire outbreak. The individual link severed is not indicated, only the section.



Hoover's new fire-detection system is controlled by a central console with duplicated fire-warning lights representing the many divisions throughout the entire factory.

The automatic detectors are set to operate at temperatures varying between 120°F and 135°F and can be compensated on a basis of rate of rise and maximum temperature to allow for other sources of fluctuation in temperatures apart from fire.

66.013.5.003

DESIGN, DEVELOPMENT AND RESEARCH IN CHEMICAL PLANT CONTRACTING*

How to avoid sources of friction among the departments of a contracting organisation engaged in plant design

by M. DAVIDMANN, B.Sc.

ONE of the main problems facing the chemical plant contractor is that of obtaining effective team-work.[1] For an adequate solution of this problem three requirements have to be satisfied:

(1) the organisation has to be divided into functional work units;
(2) line relationships have to be defined; and
(3) functional relationships have to be defined.

An organisation's work tasks change in size and scope. Fresh problems are continually arising. Here we are concerned with difficulties arising from misunderstood functional relationships and from a division of work which is not functional, between the design groups and other work units within the chemical plant contractor's organisation. A process of working-through these problems is applied with illustrative examples. The cause of the difficulty is established, not in order to attach blame, but to ensure that the cause is removed. The organisation is then altered or functional relationships are defined, by policy decision, thus resolving the difficulty.

The process of working-through is not easy to carry out, but the results obtained by doing so are of value. Each policy decision is recorded and published within the organisation, so that, whilst efficiency of organisation is increasing, there emerges an ever-clearer picture of the chemical plant contracting organisation and of the responsibilities of its constituent work units.

Requests for Immediate Action

The unexpected request for immediate action in connection with the occasional emergency is made. A system of work planning[2] assists in assessing whether this work can be done without serious delay to other work and also assists in deciding priorities. In addition, and in each case, the cause of the difficulty is sought through successively higher levels of management until it is clearly established. Executives have failed to work together, or there exists some other management problem.

Design

The following serves as an example. Suppose that a particular plant contains a by-pass line from a high-pressure to a low-pressure gas main. The by-pass, which contains an automatic control valve, safeguards a gasholder. During commissioning the chemical engineer finds that the by-passing system has insufficient capacity for its purpose, so that it has to be redesigned and modified. This constitutes an "immediate action" request. Not only is the necessary work done, but the matter is investigated.

The procedure that was followed could have been that the chemical engineer specified fluid flowrates, pressures, temperature and permissible pressure drop across the control valve. The instrument engineer's specification for a suitable control valve could have been accepted. The mechanical engineer could have determined line sizes, both upstream and downstream of the control valve, and the layout. The chemical engineer, in turn, could have approved the drawing.

The capacity of the by-passing system is restricted not by the control valve, but by the pipelines upstream and downstream of the valve, the lines being too small. The chemical engineer, while examining the drawing, had compared the by-passing arrangement with his flowsheet and, as these line sizes had been determined within another group, he had not checked them.

It thus becomes apparent that two design groups are, in this instance, doing overlapping work. Both Chemical Plant Design Group and Mechanical Design Group are specifying pipe sizes, and it is not clear where one group's work stops and that of the other starts. In this case it can be decided that, as Chemical Plant Design Group are responsible for satisfactory performance, they also have to be responsible for specifying all pipeline sizes. And thus the cause of the "immediate action" request is established and removed. Difficulties of the type illustrated by this example require a policy decision at the level of the Technical Department's manager.

Planning

Another example can be the sudden requirement for the performance testing of a small plant, at a contractor's own works, within a week of receiving the request. Say that a delay of two months had occurred between receipt of order by Sales Department and issue of timing chart by Planning Department. Delivery of the plant may have been promised nine months from receipt of order and the initial delay had already caused dislocation of work. The policy of working-through and resolving each request for immediate action had not been instituted and the matter

* Article received for publication July 27, 1959.

had not been investigated. Furthermore, that Chemical Plant Design Group had been unaware that performance testing of this plant was imminent. It was decided to take up both instances.

The lesson learned is that this group's work takes place both at the beginning and at the end of a contract. To enable it to plan its work, early notification of receipt of order and of overall timing plan are required. Also, this group's overall timing plan has to be kept up to date by Planning Department, so that the group can adjust its work plan in accordance with progress made by other work units.

A difficulty of the type just illustrated requires a policy decision at a level higher than that of the Technical Department's manager.

A further example of a request for immediate action is the requirement to start work immediately on a contract the moment the group is notified that the order has been received. This is usually caused by delay between receipt of the order and notification to the group; and/or by an insufficient time allowance for the planning of the work in the estimate of delivery period. However, such a request for immediate action may also be the result of a policy decision to quote the shortest possible delivery time to obtain the order. Assuming the group to be fully loaded, then the initial policy decision results in further policy decisions being required when the order is received, to decide relative priorities and permissible delay to other work.

Development

Difficulties can arise between a Chemical Plant Design Group and a Development Department. The following are typical examples:

(1) The design engineer, in Chemical Plant Design Group, is responsible for work on a particular type of unit process plant. He may be approached by a development engineer with the request for information on how he designs his plants. Detailed information is requested to enable the development engineer to design a plant of this type which will form part of a plant at present being designed by Development Department. The design engineer refuses to give this information, reporting his action to his executive superior.

The design engineer considers that to give comprehensive information on his own methods and experience will involve a considerable effort on his part. Indeed, he will not be able to pass on his accumulated experience and he is, indirectly, being asked to supply a few factors and coefficients for the development engineer to use. As design engineer he is being given insufficient data to carry out the design and the development engineer for his part will have insufficient practical experience to use critically any information given to him. Should Development Department's plant fail to achieve specified performance which in his opinion is a distinct possibility, then he, the design engineer, may be held responsible.

The development engineer considers that as this unit process plant is part of a complete new process plant in course of development, it has to be designed by Development Department, as they are responsible for the success or otherwise of the plant as a whole.

(2) For an inquiry two specifications can be received by a Commercial Department for the same unit process plant, one originating from Chemical Plant Design Group, the other from Development Department. The Chief Chemical Engineer considers this to be a straightforward inquiry; the Chief Development Engineer considers that as no plant of this large size has been built before it clearly constitutes development work.

(3) A design engineer, on contacting the supplier of a certain type of specialised equipment, finds that a quotation is being prepared by this supplier for Development Department. But Chemical Plant Design Group, acting for the organisation as a whole, have some considerable time ago negotiated a favourable agreement with this supplier, which results in considerably reduced costs with consequent improvement in the competitive position. Development Department are unaware of the existence of this agreement and have phrased their inquiry in such a way that no benefit is obtained from the agreement.

The head of the Chemical Plant Design Group is the Chief Chemical Engineer, and he is responsible for chemical engineering design, for commissioning and proving. The Development Department's manager, the Chief Development Engineer, is responsible for the development of new processes, of new design methods and of new plants. In addition, there is the Research Department, engaged on pure research. Each of these three work units carries out chemical engineering design for inquiries and contracts. Which unit does the work depends on the degree of novelty.

Considering the Chemical Plant Design Group and the Development Department, it may not be clear where the work of one group ends and where that of the other starts. Sometimes the engineers in the two groups may be attempting to do the same work and consequently a large amount of work is duplicated. There may exist a decided lack of communication between the two groups, with the result that one group derives little benefit from the work of the other. However, plants designed by Development Department generally contain some parts designed by Chemical Plant Design Group, so that the two groups appear to work together in harmony. In fact, they may be competing against each other for work, a struggle for ascendancy taking place between them. Such conflict is detrimental to the organisation as a whole.

It appears that the work to be done by each group has not been stated clearly, so that responsibility for work cannot be assigned to one or other of the groups. Functional relationships also have not been clearly defined; this being another reason why responsibility cannot be assigned clearly.

The organisation's task, as far as this analysis is concerned, is to provide chemical plants for customers. To carry out this task, the work is divided. Development Department is charged with developing new processes and design groups are charged with designing plants. As organisation, to be effective, has to be functional, all design work has to be done by the design groups and all development work by Development Department.

A design group may require development work to be carried out in connection with a design method or in connection with basic data required for design. This should be done by Development Department, at design group's request, for the design group. Development Department may require design work to be carried out in connection with a development project. This should then be done by the design group for Development Department, at the request of Development Department.

However, this procedure still leaves room for doubt about the division of work between the two groups. It is not clear at what stage any particular process ceases to be a development matter, to be dealt with from then on by Chemical Plant Design Group. Neither is it clear just who is responsible for the performance of a pilot or prototype plant. However, as Development Department is charged with developing new processes—this being a direct contribution to the organisation's task—they have to be responsible for such work. It follows that as long as a

plant is required by Development Department to enable it to develop a new process, the plant thus being paid for out of their development budget, they are responsible. If a plant is required for production purposes, being paid for by a customer, Chemical Plant Design Group is responsible. Hence as a pilot plant's purpose is to develop or prove a process, and as it is paid for from Development Department's budget, Development Department is responsible, design work being done for them by the design group. A prototype plant is a production model, paid for by a customer; Chemical Plant Design Group is responsible, development work being done for them by Development Department. Development Department is responsible for pilot plants; Chemical Plant Design Group for prototype plants.

It is further clear that Development Department would not be charged with developing a new process were the relevant information already available to the organisation, and, similarly, a design group would not ask for development work to be carried out on basic data or design methods, should the information be available already. It follows that the function that has been assigned to Development Department is, in fact, the search into the unknown; that is, research.

If a design group is responsible for designing, it is responsible also for the quality of its design work. For example, the Chief Chemical Engineer is responsible for chemical engineering design, for commissioning and proving, for satisfactory operation and performance of the plants designed by his group. He is therefore responsible also for comparing actual results with predicted results and for correlating conclusions so as to improve future designs. It is this process of comparison, correlation and improvement which is called development.

At this point of the analysis, one may consider also the relations between Development Department and Research Department. Conflict may exist between these two work units also, Development Department attempting to take over research work. Similar conflict may exist also between Development Department and Mechanical Design Group.

The picture that may then emerge is that of a large work unit, namely Development Department, without real function, trying to find a purposeful existence and satisfying work, doing this by attempting to take over work from surrounding groups and thus coming into conflict with them. The overall picture would then be of an organisation under internal stress over an appreciable area of primary activity.

Design and Research

To ensure effective team-work between Research Department and the design groups, the division of work between them has to be clearly stated and functional relationships have to be defined, as indicated by the following example which defines the responsibilities of, and functional relations between, a Chemical Plant Design Group and a Research Department.

Definitions

In an effective organisation each work unit has to be responsible for, and carry out, a separate specialist function essential to the carrying out of the organisation's task. In the case of the chemical plant contractor, the organisation's task is to provide chemical plants and this task may be subdivided functionally into "direct" and "indirect" work tasks.

A direct work task is one which is directly concerned with the carrying out of the work of the organisation as a whole, examples being the designing of a plant for a customer, or research into new processes so as to extend the range of plants offered to customers.

The executive responsible for carrying out a direct work task is the "responsible" executive.

An indirect work task is one which is indirectly concerned with the work of the organisation as a whole. Examples are the work done by a personnel department or that done by an executive in one work unit who is providing a specialist service for the "responsible" executive in another work unit.

The executive responsible for carrying out an indirect work task acts as specialist adviser; that is, he is the "prescribing" executive.

Relationships between executives in different work units are functional relationships. Of the two executives concerned, one is "responsible", the other "prescribes". The responsible executive is fully responsible to his executive superior alone for obtaining specialist advice, for accepting or rejecting this, and for reporting useful results back to the prescribing executive. The prescribing executive is fully responsible to his executive superior alone for giving specialist advice and for the quality of his prescription.

The same executive may be responsible for the carrying out of both direct and indirect work tasks. Where this is not clearly seen, and when the difference between the two types of tasks is not understood, then difficulties may be expected. It is important, therefore, that the type of task be clearly realised, in each case, by the executive who is carrying it out.

Chemical Plant Design Group

The head of the Chemical Plant Design Group is entitled Chief Chemical Engineer. He is responsible for chemical engineering design and development, for commissioning and proving, for satisfactory performance and operation of the chemical plants designed by chemical engineers working in this group. By development is meant the comparing of actual with predicted results and the correlating of the conclusions so as to improve the quality of the group's work. All chemical engineering design work that requires to be done within the organisation is carried out by chemical engineers working in this group. Their work consists of both direct and indirect work tasks. Their direct tasks consist of chemical engineering work on plants for customers; their indirect tasks consist of carrying out similar work for the organisation's other work units.

Whilst carrying out a direct work task, the chemical engineer is the responsible executive. Whilst carrying out an indirect work task he is the prescribing executive.

Research Department

The head of the Research Department is entitled Research Manager. He is responsible for effectively searching for new processes. All research work that requires to be done within the organisation is carried out by scientists working in this department. Their work consists of both direct and indirect work tasks. Their direct tasks consist of searching for, and evaluating, new processes. Their indirect tasks consist of carrying out research work for the organisation's other work units.

Whilst carrying out a direct work task, the scientist is the responsible executive. Whilst carrying out an indirect work task, he is the prescribing executive.

Author's Note

We have defined here the division of work and the functional relationships between two work units, but not the complete activity of either, being concerned only with that part of each work unit's activity which may affect the relations between them.

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General view of Goodyear Pump stand at the 27th American Chemical Exposition.

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NEW PLANT AT THE 27th EXPOSITION OF CHEMICAL INDUSTRIES

A review of the new designs of processing equipment which appeared at a recent American exhibition

by C. J. PRATT, B.Sc., M.I.Chem.E.

THIS Exposition, more popularly known as the "Chem Show", was held recently in the New York Coliseum. Some 650 exhibitors took part, including several firms from Europe. Although the Show was not open to the general public, attendance was believed to have been well over 50,000 and many sales engineers reported a satisfactory level of serious inquiries. A whole volume would be needed to describe all the major exhibits in detail; hence this account will be confined to typical new items observed. Although the concept of unit operations is now regarded in some circles as being unfashionable, it is at least a very useful basis for studying large exhibitions, and a review of the Chem Show on these lines affords at the same time a convenient year-end way of summarising recent chemical engineering developments in the U.S.A.

Fluid Handling

(*a*) *Pumps.* Several new types of pumps were seen among the numerous models on display. An item of particular interest was the recently introduced Goodyear pump, already well established in the U.K., which was designed to handle viscous liquids and thick slurries. It is a screw-type, self-priming pump with a suction lift up to 30 ft, and is available in three models; the largest delivers about 220 gpm at 200 ft total head. The screw is sealed by a star-type plate wheel made of a special rubber compound which meshes with the pump helix in a manner suggestive of a worm reduction unit. Another pump of interesting design shown, and also intended to handle thick liquids and slurries, was the Milton Roy-Oliver diaphragm slurry pump, which has a controlled volume accuracy of ±2%. It can handle slurries up to 60% solids at capacities up to 180 gph and pressures up to 90 psig (Fig. 1).

A free-piston, three-chamber pump was demonstrated by the Crossley Machine Co. and was said to be suitable for virtually any liquid, from molten metals at 2000°F to ice-cream. Standard models will soon be available in capacities from 5 to 1000 gpm and with heads up to 200 ft. The Tri-Rotor Co. showed an unusual positive-displacement rotary pump with manual controls which permit the operator to adjust the delivery volume without affecting the operating pressure. At the same time, an automatic, variable volume control can be provided should this be desired. This pump would seem to have a number of useful proportioning and control applications. Other recently introduced pumps exhibited were the new LaBour SZ—a single-stage, non-priming centrifugal designed to handle large volumes of entrained gas—and the Goulds range of Penton-coated pumps. Penton, a chlorinated poly-ether, is said to resist most materials (except fuming acids)

up to 250°F or even higher. An all-PVC centrifugal pump with mechanical seals of Teflon, carbon, ceramics or Stellite was shown by the Vanton Corp.; this ought to be a welcome item to many engineers.

(*b*) *Valves and Fittings.* The number of ingeniously-designed valves continues to grow and current emphasis is on ball-plug valves, which offer several advantages such as simplicity and low pressure drops because of the straight-through flow pattern. The Hydril Co. has a range of such valves in which the spherical plug is mounted on accurately positioned end bearings. A small clearance is maintained between the plug and mating parts and sealing is effected by means of compressed packing rings. An API series is available up to service ratings of 10,000 psi.

In another design of ball-plug valve, as made by such companies as Cooper Alloy, Putnam and Jamesburg, the plug is aligned and sealed by substantial guides of Teflon or other suitable material. Ranges from ½ in. to 12 in. are available from some firms, and in certain cases from 100 to 300 psi according to size. The Duriron Co. has also used Teflon in plug valve design; in their new "Sleeveline" range, which is available up to 6 in. diameter, a Teflon sleeve provides a seal between a tapered plug and the body which is made of ductile iron or stainless steel. The liberal use of Teflon in plug valve design renders lubrication unnecessary and greatly improves operating reliability. It is understood that some of the Carbon companies are also offering ball-plug valves made of graphite or chemically resistant carbon materials.

Materials Handling

A new, non-jamming, side-entry, rotary air-lock feeder was shown by the Young Machine Co. Inc. This device incorporates no adjustable or flexible tips and is available in sizes up to 18 in. In the pneumatic conveying field, the Simon-Carter Co. offered their type-D aspirator, a new device to reduce the air required for aspiration in pressurised conveyor systems. This firm also advertised their Sonic valve, which is used to balance the pressures in several conveyor lines powered by a single compressor. The operating principle is based on a special needle valve which creates a sound-barrier effect between the compressor and the line resistance in each case, to give a constant mass-flow. In the mechanical conveyor field, a new type of Hapman "Cable-Veyor" elevator was shown. This machine employs a cup-and-cable assembly running inside vertical tubes, and internal parts can now be supplied covered in neoprene for special applications.

Liquids-solids Separation

(*a*) *Filters.* There appears no limit to the ingenuity displayed in filter design and typical cases are the Read Standard Co.'s wet cake and dry cake machines. The former is essentially a small automatic plate and frame filter, intended for thickening slurries containing as little as 100 ppm of solids. The dry cake machine is also of plate and frame design, but uses a travelling medium. It is automated for short-cycle operation (0.5 to 4 min.), and by operating only during the initial period of the conventional batch filter cycle a much higher overall filtration rate is claimed. Of much larger proportions is the Fred Carver Co.'s automatic hydraulic filter press, available in areas up to several hundred square feet and capable of operating at pressures up to 6000 psi to yield virtually dry cakes. This machine is, in effect, a horizontal type of oil press with automatic discharge facilities.

Several novel designs of leaf-and-shell type batch pressure filters were shown. In the new HR model made by Sparkler, pre-coating and filtration are performed with the leaves in a horizontal position. Cake discharge is accomplished by rotating the leaves mechanically to a vertical position inside the shell and rapping the assembly to dislodge the cake, which is removed from the vessel by means of a screw. The machine can be fully automated if desired. For those operations still best performed on a nutsche filter, the Enzinger Division of the Duriron Co. offered a new range of pressure machines with dry or slurried cake discharge, as desired, and capable of operating up to pressures of 300 psi. Another design of pressure filter, the Funda, was displayed by the Rodney Hunt Co., and in this horizontal leaf machine the cake is discharged by spinning the leaf assembly by means of an electric motor, on an automatic time-cycle basis.

In the continuous vacuum filter field, a versatile, all-plastic machine was shown by Dorr-Oliver Inc., while a drum filter of recent design, and which uses a rotary belt

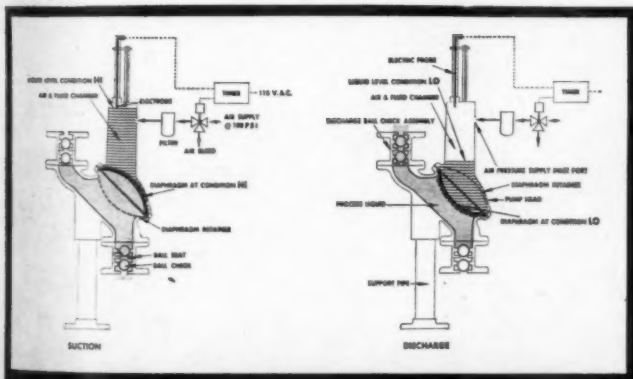


Fig. 1. The Milton-Roy-Oliver diaphragm slurry pump, with a controlled volume accuracy of ± 2%.

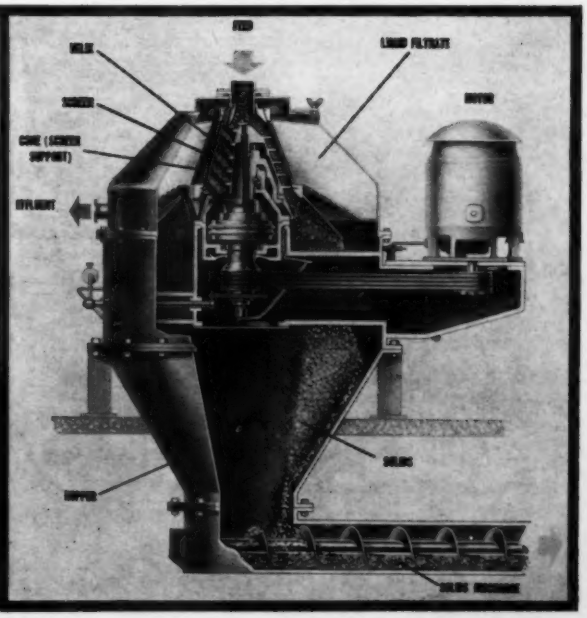


Fig. 2. Continuous vertical screening centrifuge exhibited by Dorr-Oliver at the Exposition.

of filter medium, instead of the customary circumferential cloth, was shown by the Eimco Corp.

(*b*) *Centrifugals.* The Tolhurst Division of American Machine & Metals Inc. announced a new centrifugal separator—The Maxi-Flex. This is a solid bowl machine, available in 18 and 24-in. diameter sizes, and it incorporates a device to give an instantaneous selection of each speed from zero to full speed. Seven different pool depths can be obtained by means of adjustable orifice plates. A number of new items was shown by Baker Perkins Inc., such as Escher-Wyss-type multi-stage centrifugals and the HS40-W horizontal pressure-centrifugal for continuous operation up to 150 psi. Vertical pressure-centrifugals and screens of various sizes were shown by Dorr-Oliver Inc. (Fig. 2) and the Sharples Co.

Liquid Mixing and Blending

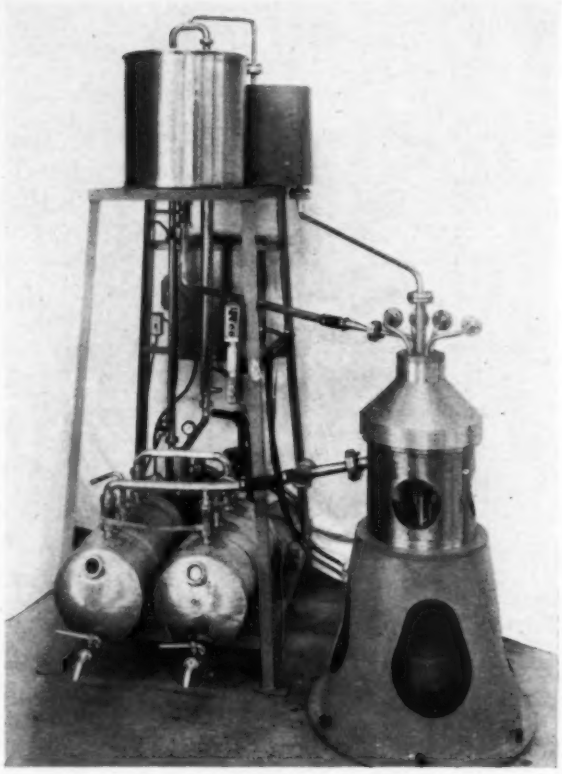
Several improved designs of homogenisers were shown; for example, the new Jet-Mogenizer of Buschman Products Inc. which is available in sizes up to 500 gph and is suitable for combining both liquid and solid phases. A special design of rotary blade induces frequencies of 20,000 cps within the liquid mass, and it is claimed that clear, 1% solutions of difficult-to-dissolve polymers such as Carbopol can be prepared in a single pass. A range of reed-type homogenisers is now available in the U.S.A. from the Sonic Engineering Corp. and models can be obtained with cutputs from 100 to about 9000 gph. Emulsifying frequencies generated are said to be in the 20,000-cps range.

Numerous mixing units were exhibited, one new model being the RL Shear-Flow head, which comprises two rotors and two stators within a compact cylindrical housing. Another unit of interest advertised was the Turbo-Tube, made by Chemineer Inc. In one form, this consists of a vertical, axial-flow impeller mounted in a long-sweep elbow and is intended for use in long, shallow tanks. Model TDT-50 is designed for insertion in tank cars and the nozzles of deep vessels; in principle, this mixer is a high-speed marine propeller mounted inside a slim draught tube. Sizes range from ¼ to 15 hp.

An unusual exhibit of very recent introduction was the MistiFier of Lamb & McBride, in which liquids and liquid/solid mixtures are converted to mists, as a means of offering maximum surface areas for blending and/or chemical reaction. A specially designed conical rotor-stator assembly having speeds up to 15,000 rpm is used to produce ultra-fine dispersions of the materials being processed (Fig. 3). Numerous applications in metallurgy, distillation and gas/liquid reactions are envisaged.

Solids Separation

Some examples of recent equipment made by the Hart-Carter Co. were shown. Always intriguing, these rotary dry separators classify mixed solids according to differences in shape and/or size, by means of indented discs or cylinders, as if by magic. In the screening field, several new entries were observed. Bartlett & Snow Inc. demonstrated one of their D.P. pulsating screens, driven by two independent eccentric vibrators which act in opposition. This is said to give both flow and counterflow action on the same cloth, leading to high capacities. Also shown was their Model P.E. screen, which develops a conveyor action and can operate horizontally, or even with uphill settings of 5 degrees or so. Maximum sizes are of the order of 4 ft × 10 ft and the machines are available in single-, dual- and triple-deck designs. Another recently developed screen was displayed by Industrial Enterprises Inc. The Novo machine, as it is called, uses a battery of electromagnetic vibrators to induce a complex wave pattern of harmonic vibrations on a simple cyclic motion as a means of achieving high capacities and freedom from blinding.



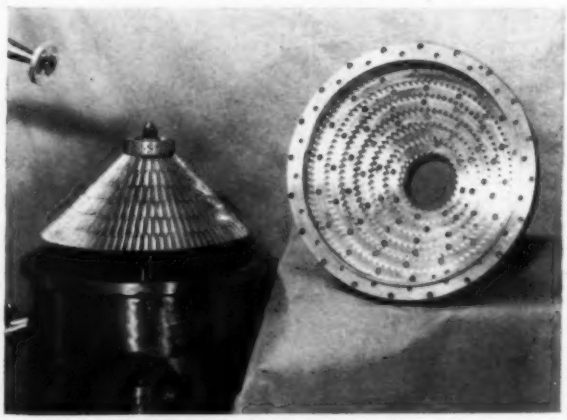


Fig. 3. The MistiFier, a conical rotor device, has speeds up to 15,000 rpm, for converting liquids or liquid-solid mixtures to fine mists.

Solids Mixing and Blending

A wide variety of mixing and blending equipment was on display. A recent development was the MacLellan dry batch-mixer made by the Daffin Co. This machine is available in sizes from 1 to 160 cu. ft and rapid mixing is said to be attained by means of internal compartments, which result in 60 complete separations and blendings after only five revolutions, occupying one minute. Another recently designed blender made by Bartlett & Snow Inc. operates on the spinning disc principle and can be used for blending dry solids or solids and viscous liquids. It can also be set to granulate or agglomerate if desired.

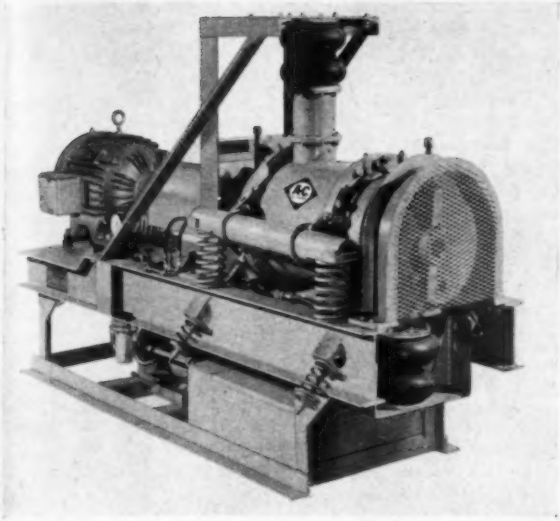


Fig. 4. The Allis-Chalmers Co. vibratory ball mill, an economical solution to many grinding problems.

Fig. 5. Giant-sized packed column distributor by Distillation Engineering Co.

Size Reduction

Advances in vibrating ball mills were announced by several firms, such as Sweco, Schutz-O'Neill and Allis-Chalmers. The Vibro-Energy mill offered by Sweco is of British origin and was developed by the Podmore and Boulton companies in Stoke-on-Trent. The Schutz-O'Neill Vibratom mill is of German design and is available for batch or continuous operation. Remarkable results are said to be obtained by these mills in certain applications; grinding time can be reduced by 75% and mill size by 90%, while permitting very fine grinding to sub-micron sizes. The Allis-Chalmers Co. claims that its 15-in. mill will out-perform a tumbling mill by 15 to 30 times, yet costs one-third less (Fig. 4).

Another recently developed mill demonstrated was the Svegvari Attritor, offered by the Union Process Co. This machine employs a stationary, vertical grinding tank, filled with small balls or other grinding elements $\frac{1}{4}$ in. or less in diameter, together with a slurry of the elements to be ground. Reduction to one micron or less can be made in about one-tenth of the time needed for conventional equipment, and the machine is but a fraction of the size of a ball mill having a similar capacity. Other new grinding equipment seen included the Entoleter ControMil, which, in the 14-in. size, will reduce 2000 lb per hour of material from $\frac{1}{4}$ in. to under 325 mesh. The Hardinge disc-roll mill—a modified Loesche machine fitted with a Gyrotor air classifier—was also of interest.

Drying and Cooling

New designs of fluid-bed driers were offered by several concerns, e.g., Dorr-Oliver, and more recent entrants to the field such as Raymond and General American Transportation. Latest designs of swept-film evaporators were demonstrated by Rodney Hunt and the Buflovak Division of Blaw-Knox. The Link-Belt Co. featured their new Roto-Fin cooler, a drum-type machine embodying deep, hollow fins spiralled round the shell which scoop up cooling water from a trough beneath the machine. Overall "U"s as high as 20 Btu/hr sq. ft °F have been achieved in some cases.

Machinery and Miscellaneous Items

A new axial-flow compressor with variable capacity control and oil-free delivery was offered to the chemical industry by Fairbanks-Morse. A range of models is available from about 800 to 20,000 cfm and with maximum compression ratios of 5 to 1 in single-stage machines. Another item of interest to compressor users was the availability of heavy-duty piston rings made in TFE-grade Teflon and also Fluogreen, which is a Teflon-glass fibre combination.

Only a few brief examples can suffice for the multitude of miscellaneous equipment items seen—many of them of ingenious design and recent introduction. For instance, Vibra-Screw Feeders Inc. have now combined gravimetric weighing with volumetric feeding in a new machine which gives accuracies of $\pm 0.5\%$, or better, on many materials. This company also makes a bin activator consisting of a vertically pulsing framework which rotates inside a bin and can be used for low-density fibrous material such as cotton linters. Another type of bin discharger, used for clays and sticky materials, was shown in action by the Pulva Corp. This is essentially a slice-and-table feed device available in sizes up to 10 ft in diameter.

In the distillation field many types of column packings were displayed. Several of these, such as the ones offered by The Scientific Development Co., were made of protruded (pierced) sheet, rolled or crimped into small cylinders and other shapes. A simple and effective design of liquid distributor for use in packed columns was shown in operation by the Distillation Engineering Co., (Fig. 5) has a number of tubes of different lengths assembled in a conical pattern from a peripheral support ring. Several such distributors in a column greatly reduced any channelling tendencies.

Among the many new operator-aids seen were the Pour-Portioner of the Sterling Norcross Co. and the Vac-U-Max cleaning unit of the Vac-U-Max Co. The former item screws into the bung-hole of a drum and is used to meter the discharge during pouring, giving a 98% accuracy. A float shut-off prevents the ingress of air when the drum is empty. The Vac-U-Max device is a compressed-air-operated, portable vacuum inducer which can be readily adapted to liquid handling and transfer—up to 2 gal. per sec.—or

used for picking up solid materials, e.g., waste, for re-use or disposal. A minimum air pressure of 30 psi is needed, and a vacuum of 8 in. of Hg, or a fluid lift of 20 ft or so, can be obtained.

A useful tool for descaling purposes seen was the Von Arx air gun. This employs a bunch of reciprocating hardened-steel needles as the impacting head and is suitable for many applications, from cleaning soft stonework to fettling castings. Air consumption is about 13 cfm at 88 psi and operation is relatively dustless.

Control and Testing Equipment

Sufficient control and testing equipment was displayed to justify a separate exhibition and for space reasons only the briefest account of a few recently introduced items can be given. This year, viscosity measurement was strongly emphasised and new equipment made by such firms as Merrill-Brookfield, Ferranti, Norcross and Brabender was shown. It is understood that co-ordination problems between all the available methods are still complex.

The application of electronics to the scientific control field continues to grow. A recent example includes the Coulter counter, wherein particles suspended in a dilute electrolyte pass through a small aperture and change the electrical resistance across the gap. This change is electronically amplified and registered as a series of particle counts. Also now available from several sources are in-line *pH* cells offering reliable electrical characteristics and low flow resistance in the line. The Photovolt Corp. has just released a new two-way (portable or in-line) instrument.

Other laboratory equipment seen included a new Ainsworth automatic recording vacuum balance (also suitable for thermogravity work) and the new dial-weight balances made by the Torsion Balance Co. These employ an internal oil-damping mechanism and a balancing spring for fast trimming purposes, instead of the more usual external beam system. To the micro-chemist, the Servel micro-mixer, with a capacity of 0.5 to 3.0 ml and a speed of 50,000 rpm, was of interest.

Some of the latest items in the automatic control category included a new Perkin-Elmer furnace atmosphere analyser capable of performing a complete gas analysis (O_2, CO, CO_2, CH_4, N and H_2S) every 10 min. and using the results to control the furnace or process. A working demonstration of a power-plant control system featuring the Bendix G-15 computer and a Beckman model 123 data system attracted much attention. Although the actual set-up simulated the operation of a large power plant, only some 10% of the available capacity was utilised. The system was said to be readily adaptable to chemical plant control, and so offers many intriguing possibilities to enterprising chemical engineers.

Robinson Brothers Install Packaged Boiler

ROBINSON BROS. LTD., a medium-sized firm of chemical manufacturers situated in West Bromwich, manufacture a wide range of industrial chemicals and, in common with other chemical manufacturers, use quite a large amount of steam for both process and space-heating purposes. The process use varies from vacuum distillation to heating drying ovens and steam-jacketed reaction vessels. Steam is also supplied to the canteen, the office block, the research department and process buildings for space heating.

The original steam-raising equipment installed in the works comprises three coal-fired Lancashire boilers, two of which were fitted with mechanical stoking equipment. As is normal, the processes carried out at Robinson Bros. require a constant steam pressure at varying loads, and in an effort to obtain a boiler which would meet the heaviest load experienced in the factory, as well as provide an alternative to solid fuel with its attendant problems, the company purchased a Model 300 Powermaster boiler as supplied by G.W.B. Furnaces Ltd. of Worcestershire.

Due to the fully modulating controls on the Powermaster, changes in steam demands can be catered for quite easily without a drop in steam pressure. The Powermaster boilers are packaged automatic units of the super-economic type with three-pass gas travel. A series of 16 models is manufactured, giving steam outputs from 517 lb. to 20,700 lb. of steam per hour. The firing system is subject to fully modulating control operating from 20% to 100% of the boiler capacity maintaining correct fuel/air ratios, so that efficiencies of over 80% are obtained on full or part loads. The adjustable cam positions for the fuel valve and air shutter are pre-set in the manufacturers' works where a comprehensive fire test is carried out on each boiler before dispatch to the customer. Boilers are sent out to the customer after the final test, and, since they are self-contained, all that is required in the way of installation is that connections should be made to the fuel, water, steam and electricity lines. The Model 300 Powermaster installed at Robinson Bros. has a maximum output of 10,350 lb. of steam per hour, and its overall dimensions are length 17 ft 7 in.; width 8 ft; and height 12 ft 6½ in.

Results of Comparison Tests

Robinson Bros. have carried out extensive tests with coal-fired and oil-fired boilers, and, as a result, have been able to make a number of useful comparisons. They found that the Powermaster, using 3500 sec. oil, produces a dependable 12.5 lb. of steam per lb. of oil. The condition and quality of coals used by the company appear to vary considerably, but the latest figures show that 1 lb. of coal produces 5.2 lb. of steam. On fuel costs alone, a ton of steam produced by coal would cost approximately 18s. 3d. and, using oil, would cost 15s. Electrical equipment on the Powermaster adds approximately 9d. a ton to the oil-firing cost, while water treatment costs are about the same for both types of boiler. Hauling of ashes and handling of coal adds further to the cost of running a coal-fired boiler, costs which are not encountered with the Powermaster. Maintenance demanded by the coal-fired boiler has so far been rather more than that required for the Powermaster. One of the ways by which steam is conserved is by metering the steam supplied to each department. By this means wasteful usage is discovered and eliminated. Other advantages of the Powermaster are that it takes up far less space than an equivalent rated coal-fired unit, and oil tank storage eliminates the handling difficulties associated with solid fuels. Operation is completely smoke-free, and the boiler-house is much more pleasing in aspect, while the operative's task is generally alleviated.

G.W.B. Furnaces feel that there is considerable scope in the chemical industry, and indeed industry generally, for the application of their packaged units, which have such advantages as high operational efficiencies, reduction to a minimum of supervision, together with a general improvement in boiler-house conditions.

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NEW TRENDS IN COOLING TOWER DESIGN—METHODS AND MATERIALS OF CONSTRUCTION

PART I

The author traces the development of cooling tower design methods and underlines the requirements of tower packings

by D. J. TOW, B.Sc.(Eng.), Dip. Chem. Eng., A.M.I.Mech.E., A.M.I.Chem.E.

LARGE quantities of industrial cooling water are wasted by a one-pass method of heat dissipation, and in many cases the available water has so little cooling capacity that it has become uneconomical for use even in the once-through cooling operation. Cooling towers are being extensively used as a solution to this problem. Rapid industrial growth and expansion have continued in the power, petroleum, chemical, petrochemical, steel and allied industries. Increases in plant production capacity have placed more severe duty on existing cooling facilities and in some cases have outstripped all available cooling capacity. Cooling towers have not only been subjected to larger and larger cooling loads, but are also being used in an increasing variety of cooling and mass-transfer operations. It has therefore been necessary for the cooling tower industry to produce more towers which would supply the colder water more economically.

This has caused a change in the practices of the past, with the result that the cooling tower manufacturers can no longer rely on established "rule of thumb" designs and stock items to satisfy industry's demands. They have to consider each case individually; to manufacture from carefully calculated engineering designs, based on specifications and standards. These specifications and standards should be based on data that have been carefully accumulated through extensive development and field testing. The cooling tower field is one about which the least of a definite nature is known. The very process of cooling is complicated, and the fact that the cooling towers are subject to the whims of the weather makes accurate prediction of performance a difficult one to make. The cooling tower, therefore, constitutes one of the most difficult items of plant equipment to specify and evaluate.

With these problems confronting industry, it has become increasingly important that more detailed knowledge of cooling tower operation and performance should be developed by individual manufacturers. The cooling tower is the largest item of commercial heat-transfer equipment in use and, accordingly, it is essential that continuous development in design, with emphasis on new materials of construction, be carried on. It is, however, only through an understanding of the basic principles involved in cooling tower design and operation that one will be able to better understand and take a more logical outlook toward new developments and their effects on the overall problem of cooling.

Development of Cooling Tower Design

In the early stages of cooling tower development there was no general uniformity in procedure for analysis and correlation of experimental data. It was based on experience factors and rules of thumb rather than on theoretical analysis as applied to test work. Robinson in 1922 and Walker, Lewis and McAdams in 1923 developed the basic equations for mass and heat transfer for counterflow operations and considered each process separately. Merkel in 1925 established the validity of the fact that the performance of a cooling tower is a function of the wet-bulb temperature, so that the difference in heat content existing between the film of air surrounding the water and the main mass of air was the driving force in the cooling process. A consideration of these facts led him to utilise the Lewis relationship to combine the coefficient of sensible heat and mass transfer into a single overall transfer coefficient based on enthalpy potential difference as the driving force.

This fundamental approach to data analysis and correlation is now the most widely accepted method throughout the industry. Later, in 1934, Lichtenstein handled the same basic equations in a slightly different manner and presented a method of plotting the basic calculations and tower characteristics. All of these analyses had certain simplifying assumptions incorporated in them. For instance, they neglect the reduction in the mass flow-rate of the water due to evaporation. This error is negligible in most cooling applications, except when wide cooling ranges are involved. Another assumption involves the use of enthalpy of a saturated mixture of air and water vapour as being a measure of the enthalpy of any mixture having an equal wet-bulb temperature. The error is in the fact that the enthalpy of the saturated mixture will be slightly greater by an amount equal to the heat content of the liquid of the quantity of water necessary to saturate the mixture. They also assume that each drop of water is surrounded by a film of air that is saturated with moisture and at the temperature of the water. In spite of the simplifying assumptions used in its derivation, the basic equation stands on its own merits.

To determine the performance coefficient for counterflow towers, the saturation enthalpy of air is plotted against temperature (Fig. 1). Knowing the hot-water temperature, the cold-water temperature, the wet-bulb temperature and the water-to-air ratio, the operating line can be drawn. Now the condition at the bottom of the tower is represented by

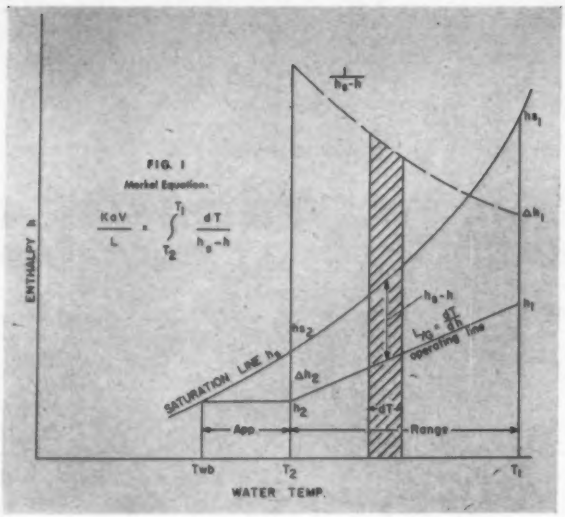


Fig. 1. Determination of performance coefficient for counterflow towers by means of the Merkel equation.

the point T_2h_2, T_2 representing the cold-water temperature and h_2 the enthalpy of the entering air. Point T_2h_{s2} is the enthalpy of air were it saturated at temperature T_2. The difference, $\triangle h_2$, may be considered as the "enthalpy potential" or driving force existing at the bottom of the tower.

The slope of the operating line is equal to L/G, since the heat lost by the water equals heat gained by the air. This neglects the reduction in water quantity in the tower due to evaporation. With point T_2h_2 and the slope L/G, the operating line is extended to the hot-water temperature T_1. $\triangle h_1 = h_{s1} - h_1$ is expressed as the enthalpy potential existing at the top of the cooling tower. The enthalpy potential then existing at any point between T_1 and T_2 is expressed as $h_s - h$, and the integral $\int_{T_2}^{T_1} \frac{dT}{h_s - h}$ corresponds to the performance index, KaV/L.

The graphical method of handling the integration to obtain the performance coefficient or index for a set of design conditions is tedious and somewhat time-consuming until a certain degree of familiarity has been gained. On the other hand, if the transfer coefficient is known, it is not possible to solve for the performance conditions, except by trial and error.

New Approach to Design Problems

To facilitate this problem, the basic data have been calculated for a number of performance conditions using the high-speed electronic digital computer. The calculated data have then been plotted as a series of demand curves. These curves represent the five variables, hot-water temperature, cold-water temperature, wet-bulb temperature, the water-to-air ratio and the performance index, KaV/L.

Any theoretical analysis of the cooling process considers only the mass and energy balances within the system and, as such, it evaluates only the performance of the cooling process; it is independent of any particular tower. Correlation between the theoretical calculations and actual test data serves to bridge the gap and makes it applicable to a specific tower.

The tower performance characteristics indicating the specific performance for a particular type, height, shape and packing of cooling tower are obtained from experimental data. These tower characteristic lines are then superimposed on the particular demand curve representing the design conditions, for selection of the most effective and economic tower arrangement.

It is clear that, regardless of the degree of validity of the theoretical basis of any method of cooling tower analysis, its application is purely a matter of empirical correlation. With the availability of a positive method of correlating and interpreting data, it is only necessary to have adequate development and pilot-plant facilities to produce reliable data which could be applied to the design of superior equipment.

Periodicals and text publications have, from time to time, offered data on various aspects of the cooling tower. The majority of data was obtained from small research-type installations, having only a fraction of the plan area of large single-cell industrial cooling towers. The difference in the effective heights of packing are also quite large. The data obtained on these small towers are often of doubtful commercial value and extreme care should be taken in accepting and using this type of data directly as the basis for designing commercial installations. The tremendous sizes to which cooling towers have grown have created a need for pilot-plant stages seldom realised in similar types of equipment. The pilot-plant tower needed by the manufacturer for development purposes, therefore, must be reasonably comparable in size to industrial units. The large pilot-plant tower is primarily used in producing reliable basic data from which it is possible to derive accurate performance data, make economic studies and select superior equipment. It is also used experimentally to tie together the overall aspects of pressure drop, air flow characteristics, drift removal, fan performance, gear selection, erection and installation problems and cost indexes.

The Fluor Products Co., American associates of Head Wrightson Processes, London, have been active in research, testing and development activities in water-cooling processes for more than a quarter of a century. This work is performed on full-scale experimental towers, one of which is an 18 ft x 18 ft x 45 ft high tower with a 10-ft-diameter fan and the other is an 18 ft x 36 ft x 40 ft high tower with a 12-ft-diameter fan. These units are capable of handling wide ranges of design conditions and physical changes. They have developed and tested various new types of distribution systems, fans, stacks and drift eliminators, packings and a multitude of possible combinations of tower components. With virtually unlimited types, shapes, arrangements and materials of construction available, the ideal cooling tower can never be completely realised; for so long as new materials of construction are brought forth, prices fluctuate, technical knowledge increases and new designs are initiated, there will always be a better combination. Adequate development and pilot-plant facilities are therefore essential to the progressive cooling tower supplier.

New Cooling Tower Materials

The cooling tower industry as a whole is looking more towards various virgin laminated and impregnated plastics as substitute materials for use in the manufacture of various cooling tower components presently fabricated from wood and metals. Various plastics have already been tried in the manufacture of drift eliminator supports, fan blades, fan stacks, distribution systems, louvre panels and tower sheathing. For example, experience has shown that some striking architectural effects can be obtained by using flat cement asbestos panelling for the outside sheathing of the towers. This covering helps to eliminate the somewhat drab appearance of the towers and makes them more attractive.

The packing or fill is the most important component of the cooling tower, for it is here that the critical problems of heat exchange are encountered. The fill provides both the splash surface and the wetted surface and increases the time of contact by interrupting the fall of the drops of water and helping to break them further into smaller and

smaller droplets as they cascade down through the tower. In a normal cooling tower about 50% of the total board feet of timber may be used to perform the duty of providing the wetted surface and repeated break-up of water.

The development of a superior packing is a challenging and painstaking engineering task. It involves the evaluation of numerous factors, including some which cannot readily be assigned a cost value. For any new type of packing it is necessary that full-scale data be developed on its performance, pressure drop, fabrication and erection. These data must then be balanced against the economics involved. Consideration must be given to whether the resultant cooling tower is to be designed on the basis of first cost or operating cost over the specified period where power (a combination of pumping head and fan horsepower) is an important factor.

The characteristics most desirable for an ideal packing include:

(1) a high overall transfer coefficient;
(2) low pressure drop;
(3) low cost of fabrication and installation;
(4) adequate strength;
(5) deterioration resistance;
(6) lightweight;
(7) ease of installation;
(8) open construction to minimise fouling; and
(9) freedom from channelling of either gas or liquid.

Not one of the above factors by itself is sufficient upon which to base the selection of a better packing. It is from a combination and balancing of the individual effects of all the above factors that a selection of the optimum packing should be made. It should be emphasised again that only the overall economics of the resultant cooling tower will dictate the final choice for its acceptance as a commercially feasible and economically sound packing.

The height of a cooling tower is determined by the design specifications and its capacity is limited by the cross-sectional area. The proper design of the tower packing makes it possible to obtain the performance with a shorter and more compact tower. High coefficients and short towers are not necessarily tied to high static pressures and therefore to high horse-power. A relatively high pressure-drop per foot of packing can be tolerated if the packing has so high an efficiency that only a few feet of packed height are required. Such packing would undoubtedly be more expensive per unit volume than its lower efficiency, lower pressure-drop counterpart. This cost differential may be partially offset by the smaller volume of packing required. Even if the total cost of the higher efficiency packing is greater than that of the lower efficiency unit, the economics for its use may be favourable because of the savings in the tower shell costs and the liquid pumping head which can be realised from the resultant shorter tower.

To be continued

Developments in Sulphuric Acid Processes

A 250-tpd sulphur-burning contact sulphuric acid plant has recently been commissioned by Chemical Construction (G.B.) Ltd. at the Billingham, Co. Durham, works of British Titan Products Co. Ltd. This latest addition to the sulphuric acid plants of B.T.P. is said to be one of the two largest in Great Britain and is the fifth sulphuric acid plant supplied by Chemical Construction (G.B.) Ltd. to B.T.P.

The plant uses sulphur as raw material to produce sulphuric acid of 98% concentration. It has been producing acid at a rate of about 300 tpd. This latest plant brings B.T.P.'s total sulphuric acid capacity at both Grimsby and Billingham to over 1000 tpd.

Sulphuric Acid from Copperas

A further development at British Titan Products, this time at their Grimsby plant, is the use now being made of ferrous sulphate heptahydrate, large quantities of which arise as a by-product from the manufacture of titanium dioxide. This development follows extensive experimental work which has been carried out by B.T.P. Three units are scheduled for the process, and already one has been reported to be in successful operation. Ferrous sulphate monohydrate is decomposed in fluidised-bed roasters using coal as a reducing agent, and the resulting sulphur dioxide is converted to sulphur trioxide in one of the existing converters. The difficulty lies in economically obtaining ferrous sulphate monohydrate ($FeSO_4 . H_2O$) from by-product copperas ($FeSO_4 . 7H_2O$), for although the monohydrate can be arrived at by evaporation, the copperas tends to melt in its water of crystallisation, producing on the heated surfaces a scale which reduces efficiency. B.T.P.'s patented process relies basically on the dehydration of the heptahydrate to the monohydrate in a spray drier. The spray driers installed for this duty at the Grimsby plant were designed and provided by Kestner Evaporator & Engineering Co. Ltd.

The fluidised-bed roasters which also perform a vitally important function in the process are of Dorr-Oliver design and not, as erroneously stated in BRITISH CHEMICAL ENGINEERING, 1959, **4**, 12, 710, of another type and make. In view of sharp competition from other makers in the field the adoption of the FluoSolids reactor is a noteworthy departure from previous custom at Grimsby. The main contractor for the entire project was Chemical Construction (Great Britain) Ltd. The unit now working is capable of producing enough sulphur dioxide to manufacture some 60 tpd of 100% sulphuric acid. When the remaining two units come into operation, enough sulphur dioxide will be generated to raise the sulphuric acid made to a figure approaching 200 tpd.

Cheaper Fertilisers Possible

A new process (Patent No. 826,221) has been developed by Chemical Construction (G.B.) Ltd. to rid power station and sulphuric acid plant stacks of their sulphur nuisance and to recover sulphur salts for use in the production of ammonium sulphate fertiliser. The prevention of the release of harmful acid fumes from stacks located in congested areas has long been sought by industry. The Chemico process of acid fume removal is said to be the simplest and most effective method ever made available. In this process ammonia gas is introduced into the flue gases between the economiser and the air heater. The gas temperature is not lowered and wet scrubbing is not used; therefore, the condition favourable for causing "stack droop" is not created.

The ammonia reacts in the gaseous phase with the sulphur oxides produced by combustion of the sulphur contained in the fuel. The product is a fog of ammonium sulphur salts such as sulphite, bisulphite, sulphate, thiosulphate, etc. These solid salts are quantitatively removed as a powder from the gas stream in the high-voltage electrostatic precipitators installed at most urban power stations. The residue extracted by this process is a mixture of ammonium sulphur salts and fly ash, and when separated from the fly ash the salts form the basis for the production of ammonium sulphate fertiliser.

The great advantage of using this residue for fertiliser production is that sulphuric acid, one of the more costly items used in making ammonium sulphate, is available in the residue. Thus the cost of producing ammonium sulphate fertiliser can be greatly reduced—at present it is losing ground to other more economically produced nitrogenous fertilisers—so that it could again become the cheapest.

COMPUTER/SIMULATOR FOR PROCESS INVESTIGATION

A NEW d.c. analogue computer built by General Precision Systems Ltd. to the specification of BP Refineries and Technical Department (Engineering Division) is now in use for investigating a wide range of dynamic problems arising in oil refining, distribution and plant economics. Known as the Control Engineering Research Electronic Simulator (CERES), it is of the general-purpose type designed to offer maximum flexibility and versatility in operation. The machine can reproduce the behaviour of process plant, either in real time using the same time scale as on the operation plant, or in condensed time when the machine time will be speeded up. If a problem can be stated in mathematical terms, the machine can be programmed quite readily by transposing variables into voltages and using the appropriate computing units. The analogue circuit is thus made to follow closely the physical system being studied. This may involve a considerable amount of prior study of plant data in order to derive the operative equations.

The simulator is 11 ft 6 in. long, 2 ft 4 in. wide and 6 ft 3 in. high; the computing components are housed in six standard 19-in. racks, three of which are force ventilated. A complete range of non-linear computing units has been included. Two types of servo multiplier are employed, one with a very fast response time and another with slower response with additional provision of velocity feedback. This allows them to be used for integration through extremely long periods. Both types of multipliers contain tapfed potentiometers, thereby enabling non-linear functions to be generated. Other non-linear computing components include diode function generators and limiters.

Computers of this type have tended to use dials for setting the potentiometers for load conditions. To meet BP requirements, this machine has been equipped with arrangements for using the digital voltmeter for this purpose. A further distinctive feature is said to be the large proportion of equations having multiplication and non-linear functions, for which provision has had to be specially made. There are servo multipliers of two distinct types each with its own attributes; one type will be used for multiplication in which high response rates are required and the second where lower rates are required or for continuous integration over periods of many hours. Both types provide for generating non-linear functions.

In addition, the engineers wished to be able to wire up or "pre-patch" their problems away from the machine so that it could be fully utilised. G.P.S. met this requirement by providing two patch panels each with a removable plug board and each sharing the computing elements so that the various sizes of problems can be accommodated.

Main features of the computer and the method of preparing a problem for simulation are illustrated (see Figs. 1 and 2). An example of the use of the machine for studying a process problem is given (see Figs. 3 and 4).

Symbols Used

a = liquid surface area;
h_d = set liquid level;
h = actual liquid level;
q_i = inlet liquid flow rate;
q_o = outlet liquid flow rate;
q_s = heating medium flow rate;
$\frac{e_s}{\rho}$ = heat content of medium transferable;
θ_i = inlet liquid temperature;
θ_d = outlet liquid set temperature;
θ_o = outlet liquid temperature;
S = specific heat of liquid;
ρ = density of liquid;
t = time.

Controllers

Level controller working on proportional band only, giving output air pressure p_h of 0-12 psig. Temperature controller working as two-term controller (proportional plus integral) giving air pressure output 0-12 psig. This could be adjusted if required to give 3-15 psig output.

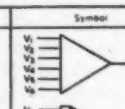
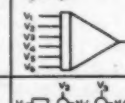
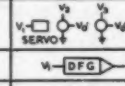
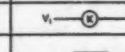
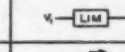
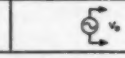
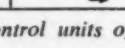
Unit	Symbol	Transfer Function	Remarks
Summing Amplifier		$V_o = -(V_1 \pm V_2 \pm V_3 \pm V_4 \pm V_5)$	Used for addition or subtraction
Integrating Amplifier		$V_o = -\frac{1}{C}\int(V_1 \pm V_2 \pm V_3 \pm V_4 \pm V_5)dt$	Used for integration (normally with respect to time)
Servo Unit		$V_2' = V_1 V_2$ $V_3' = V_1 V_3$ $V_4' = V_1 V_4$	Outputs shown when used as a multiplier Inputs in circuit enables unit to be used for divide square powers and generate non-linear functions
Diode Function Generator			Will transform one arbitrary function into another a reset-on-slope shown in graphical form
Coefficient Potentiometer		$V_o = K V_i$ $0 < K < 1$	For insertion of constants Multiplication by a fixed number less than 1
Limiter/Inverter Unit			Used for limiting a quantity can also provide saturation backlash hysteresis etc
Waveform Generator			Feeds a signal or disturbance into the system These signals can be single or repetitive and can be square triangular or ramp functions over a range of 500 cph to 1 cycle in 33 minutes

Fig. 1. Control units of the CERES analogue computer.

Patchboard used for interconnection of computing units. Where problems are frequently encountered, a pre-wired detachable plug board can be used in place of the patchboard. Control centre provides facilities for starting the simulation and holding or freezing the simulation at any instant. It also enables the machine to automatically reset to initial conditions and work repetitively. Should any units of the machine overload, this is indicated on the overload lamp and the simulation is "frozen" at that particular instant. In addition to the above units, it is possible to incorporate various passive networks, etc., as and when required.

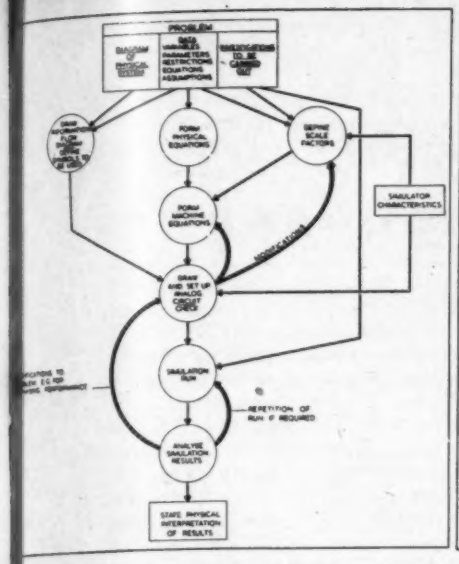


Fig. 2. Preparation of a problem for analogue simulation.

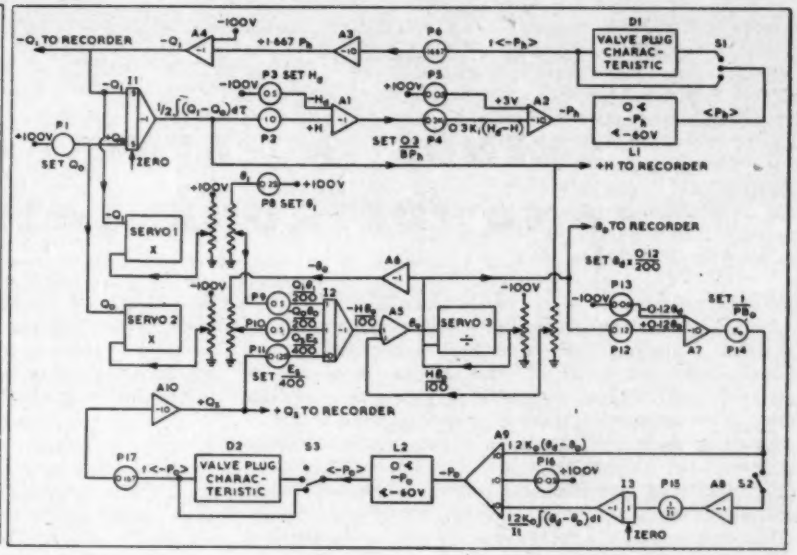


Fig. 4. Simplified analogue circuit. High-speed recorders can be connected to provide instant digital voltage read-out and trends of variables with time.

Example of Analogue Simulation—Storage Heater Unit

Problem

The system is a tank with outflow which is subject to demand disturbances and the inflow of which is controlled by the liquid level in the tank. The temperature of the outgoing liquid is controlled by throttling the heating medium valve, $V2$, through the action of a temperature controller. What are the effects of demand disturbance on inflow, level and exit temperature? Is the system stable? Which is the better valve characteristic to use for $V1$, linear or equal percentage? What type of temperature controller is required?

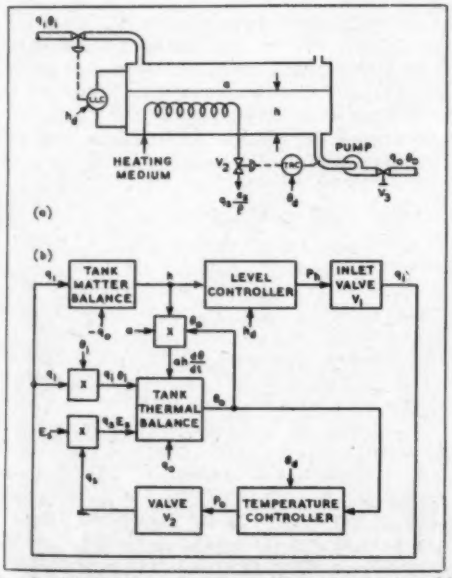


Fig. 3. (a) System diagram. (b) Information block diagram.

Assumptions

Neglect effect of level in tank on outflow rate. Neglect dynamics of valve motors.

System Equations Used (see Fig. 3)

In Fig. 3a a diagram of the tank system used in the problem is given, and in Fig. 3b the information block diagram of the tank system is shown.

(*a*) *Mass Balance*

$$\frac{dh}{dt} = \frac{1}{a}(q_i - q_o)$$

(*b*) *Thermal Balance*

$$\rho S \frac{d\theta_o}{dt} = \frac{1}{ah}(\rho S q_i \theta_i + q_s e_s - \rho S q_o \theta_o)$$

$$\frac{d\theta_o}{dt} = \frac{1}{ah}\left(q_i \theta_i + q_s \frac{e_s}{\rho} - q_o \theta_o\right)$$

(*c*) *Level Controller*

$$p_h = 6[1 + k_1(h_d - h)] \qquad k_1 = \text{a constant}$$

(*d*) *Inlet Valve V1*

$$q_i = 1000\left(1 - \frac{p_h}{12}\right) \qquad 0 \gtrless p_h \gtrless 12$$

(*e*) *Temperature Controller*

$$p_o = 6 + \left[\frac{12}{100} k_o (\theta_d - \theta_o) + k'_o \int (\theta_d - \theta_o)\, dt\right]$$

k_o, k'_o are constants

(*f*) *Heating Medium Valve V2*

$$q_s = \frac{200}{12} p_\theta \qquad o \gtrless p_\theta \gtrless 12$$

Scale factors are used to transform the system equations to machine equations which are then set up on the simulator. The factors are chosen so that the range of any given variable is spread over a reasonable span of the 100 volts available on the machine taking into consideration the limits of a machine variable must be ± 100 v.

CERES can be used extensively in training plant operators. Both typical and exceptional situations can be simulated and operators trained at negligible cost in handling them.

TRENDS IN PROCESS CONTROL AND INSTRUMENTATION—PART 2*

IN the concluding paragraph of the first part of this article, published in the preceding issue of this journal (page 110, February issue), attention was focused upon the usefulness of data logging equipment for simplifying the task of the plant manager or process operator at a plant where a large number of variables have to be controlled and recorded. Where the value of a controlled variable falls outside its prescribed limits, the logger may initiate corrective action or other suitable emergency measure. Data loggers not only reduce the amount of indication in the control room, but also provide a record which is easy to follow. A possible snag in the use of data loggers is that, as more and more measurements become concentrated in one unit, the consequences of failure on the part of the unit becomes more serious.

Safety and warning devices are another important section of instrumentation technology. These include sequence timers which, on batch processes, may control a series of interlocked operations.

In most control systems, loops are generally very simple—an advantage, since this is a feature compatible with reliability and low cost. In the future, however, it can be foreseen that greater complexity will be unavoidable and increased computational facilities and co-ordinating will be required.

Another Example of the Use of Computers

Returning to the subject of the use of computers in control systems, another contribution in this sphere, worthy of note in this survey, has come to light. LEFKOWITZ and ECKMAN[27] (the authors of one of the first useful treatises on automatic control) outline the use of an analogue computer for the prediction of the best control of two first-order reactions carried out in a batchwise operation where the reaction response is influenced by pressure. Basically, the progress of the reaction is analysed intermittently and on each occasion of sampling the computer estimates the optimum operational approach to the required product. From this the reactor pressure is adjusted and the effect of this change is observed when next the batch is analysed, and so on.

The Mechanical Engineers Conference on Automatic Control

The majority of the papers presented were devoted to features of servo-mechanisms and some of their important components such as control valves; many of the papers were of pure mechanical engineering interest, since they were concerned with such topics as automation of automobile manufacture, control of gunnery systems and so on. One subject which came in for a great deal of attention was control valve characteristics. WILLIAMS,[28] for example, discussed the problem of instability in piston-type control valves, and he shows that the effect of oil-momentum forces in hydraulic systems is to reduce the damping in the servo-mechanism. Through an analysis of this effect he is able to propose a design criterion for electro-hydraulic valves in which the effects of load stiffness and oil compressibility are taken into account.

Another paper relating to control devices was given by SUNG and WATANABA[29] who were concerned with the design of high-performance electro-hydraulic servo-systems for the positioning of loads of high inertia. They consider that it is advantageous to use an elastic mechanical linkage between the servo-actuator and the device whose position is being controlled. For this purpose the rotary servo-motor is superior to the rectilinear servo because it minimises the feedback effect of the structure. Perhaps the paper more closely approaching the interests of the process man was that given by DAVIES[30] on the control of gas-turbine-driven alternators, in which arrangements were described for controlling the flow of liquid fuels to propulsion units. In one case, for controlling the flow of iso-propyl nitrate, the alternator frequency is sensed by speed of rotation and a centrifugal governor sets the position of the fuel valve. Another system of interest described in this paper, permits a gas turbine to be driven by gas supplied from ground with a change-over to hydrogen peroxide once conditions for flight have been established.

A paper on electrohydraulic copying machines[31] for controlling the operation of machine tools was of wider interest, since it described an experimental machine built up from standard building bricks. This paper showed that it is possible to build a comparatively sophisticated control system in this manner, with considerable saving in expenditure. The system described also demonstrates the performance advantages of coupling electrical detecting and computing elements to hydraulic output devices. The main lesson from a paper describing the automatic control of the high-speed manufacture of food cans[32] was that many methods alternative to those described could have been used. But the need to have a reliable plant caused the emphasis to be placed upon simplicity.

A Mechanical Analogue Computer

SMITH[33] described a design of mechanical analogue computer utilising mechanical methods of calculation and hydraulic servo-mechanisms. The author believed that this type of computer had been neglected by industry especially for instances where the quantities to be computed can be represented by shaft rotations and where the final action required is a mechanical output. The case for a mechanical solution will not be so favourable, however, when one or more of the quantities to be handled appears not as a mechanical analogue, but as a voltage. Even then there may still be advantages in the use of this kind of computer. Such a computer is suitable for addition, multiplication and integration. An example of the use of two latter operations is where it is required to know the rate of working; for example, the product of speed and weight of a conveyor with a va iable speed drive. Its advantages are summed as compactness, reliability with a minimum of

* Part 1 was published in the February, 1960, issue, p. 110.

† Symposium on Recent Mechanical Engineering Developments in Automatic Control held by the Institution of Mechanical Engineers, London, January 5 to 7, 1960.

maintenance, very low energy demand, stability of output, and absence of requirement for a special power supply.

Flow Characteristics of Valves

SHEARER[34] discussed the resistance-to-flow characteristics of valves and the factors influencing them. He shows that the discharge coefficients of orifices with gases flowing through them are considerably higher than is the case with liquids. He also points out that the resistances of very small hydraulic nozzles differ considerably from those predicted by the simple orifice equation when the Reynolds number for the flow is less than 250. The flow resistance characteristics of pneumatic valves are, however, more predictable, although bistable flow conditions have been observed which sometimes produce a change in flow resistance. Included in this paper is a convenient procedure for calculating the discharge through an orifice for constant downstream pressure and variable upstream pressure.

Work carried out at the R.A.E., Farnborough, on electro-mechanical servo-mechanisms provided the substance of the contribution from G. T. EYNON.[35] Here again this work was concerned primarily with rocketry; nevertheless, there was much of interest in this paper for those engaged in other fields. In the main the paper was devoted to electro-hydraulic servo-mechanisms with a single stage of hydraulic amplification, and the conditions which have to be satisfied for their satisfactory operation. Of considerable interest was an account of a hot gas servo-mechanism which has proved successful in practice when using gas obtained from the decomposition of such fuels as high test peroxide at 550°C or iso-propyl-nitrate at 1100°C.

EYNON expressed the view that similar techniques might be adopted industrially for plant and process control where high-pressure steam or other gas is readily available and where, for some reason or other, hydraulics or high-powered electrical equipment is undesirable. In discussing the pros and cons of hydraulic and pneumatics for servo-controls, he concludes that for powers of up to 5 hp, pneumatic servo-systems may often be preferable to hydraulic systems. Such systems may be operated at system pressures of up to 4000 psi or more.

Bubble Formation at Discontinuities

A number of investigations on the flow characteristics of piston-type control valves were reported by MACLELLAN and co-authors.[33] They point out that little of general validity has so far been published on the discharge characteristics of control valves, and discharge coefficients varying from 0.6 to 0.8 have been quoted for pilot valves. Included in the paper is a discussion on the formation of separation bubbles which arise when a laminar boundary layer separates from a solid wall through the presence of a discontinuity in the wall or through an adverse pressure gradient. The separated layer may attach to the downstream section of the wall as a turbulent boundary layer and it is between the point of separation and the point of reattachment that the bubbles will occur. For Reynolds numbers (based upon free stream velocity and displacement thickness of boundary layer at separation point) less than 500, the length of a bubble is of the order of 10^4 times the displacement thickness of the boundary layer. For greater values of the Reynolds number the reattachment takes place at points much closer to the discontinuity and in this case the length of bubble is of the order of 100 times the displacement thickness.

As a result of this phenomenon and others, such as the initiation of cavitation in the shear layer enclosing the bubble, the flow coefficient of an orifice varies over a wide range with geometrical configuration. It may attain a value as high as 0.9, but whether higher values are obtainable requires further investigation to decide. It was shown by the authors also that the minimum pressure in a valve may be influenced greatly by quite small changes in valve geometry. For example, the presence of one additional downstream boundary wall capable of inducing bubble formation can cause the ratio of static pressure (at a point well downstream of the separation point) to valve pressure drop to fall from -0.5 to -0.9. The addition of an upstream boundary can counteract this effect. Further work is thought to be necessary to establish in greater detail the consequences of such geometrical effects; similar remarks apply to the effects of cavitation upon flow characteristics of valves.

LEVETUS[37] indicated in his paper methods of controlling machines through hydraulic systems of a simple type not requiring electrical or electronic measurements or links. Of interest was the proposal to govern a hydraulic motor not by means of a signal obtained from the pressure drop across an orifice, but instead by the comparison of outputs of one metering pump with the volume accepted by another.

The Field of the Control Specialist

LAWRENCE[38] examined the role of the control specialist in industry, the type of man who would be either a consultant inside a large industrial organisation or be associated with a firm of engineering consultants. Influencing the decision to employ him is the size and character of the industrial undertaking, how large it must be before it can afford a full-time specialist, and the types of problem which require a specialist approach for their solution.

In this latter connection LAWRENCE puts forward a number of suggestions which deserve mention here. He points out, for example, that with many design problems there will often be too little information or else the available information will be too complex to be handled, in which case simplifying assumptions will have to be made. Stressed by the author is the importance of recording the assumptions, since the confidence which can be placed upon the data derived from analogue tests rests upon the validity of the original assumptions. He gives a warning that in report writing there may be a danger that the writer of the report may lose sight of the practical aim of the report, with the result that a concentration is made upon its appearance. At the same time not only may the essentially practical purpose of the report be overlooked, so too may be the original assumptions underlying the treatment of the subject-matter.

After giving examples of the kind of problem which require specialist attention, LAWRENCE draws a number of useful conclusions. One is that because the engineering of one control problem looks much the same as one already solved it does not follow that they have the same stability. A second example shows that one has to be cautious of forecasting positively from such assumptions that all relations describing a system are linear; and finally there are many jobs where the quickest answer may be obtained from straightforward engineering trial-and-error methods. There is another danger that the specialist might become so deeply involved in the complexities of his own creation that he may come to rely upon computer solutions simply for their own sake. What is needed is an overall approach where what is positive and significant is selected and what is extraneous is left to one side. If there is no computer available, then simple slide-rule calculations will have to do or one may have to rely upon intuition even to arrive at the best approximation. The success of such a procedure will depend upon the skill of the engineer who does the guess-work. To illustrate the point, the case of Sir Charles Parsons is given. He drew free-hand the aerofoil profile for turbine blades which could only be improved upon through wind tunnel testing and the accumulated experience of 40 years.

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GUIDE TO PROCESS INSTRUMENTATION—PART 2

MEASURED OR CONTROLLED VARIABLE: MOISTURE

Type	*Application*	*Range falls within stated limits*	*Accuracy as percentage of full scale reading or other definition*	*Suitability for automatic control*	*Remarks*	*Maker*
Psychrometer wet and dry bulb type. Mercury in steel or resistance thermometer elements.	Relative humidity of air and gases. Atmospheres employed in drying processes	0 to 100% r.h. 0 to 150°F	±1 to ±2	Remote reading and recording. In conjunction with temperature controllers, will provide automatic control	Tables required to convert reading to relative humidity of wet and dry bulbs. Hazard is that wet bulb may run dry	B 6. C 1. F 10. N 3.
Dimensional change hygrometer; e.g., employing hair or wood	Relative humidity of gases and drying atmospheres	0 to 100% r.h. Range of temperature depends upon material undergoing dimensional change	±3	Local and remote reading and recording, proportional and on-off control	This type is not suitable for extremes of humidity; i.e., not below 15°F or above 160°F in the case of the hair type	C 1. F 10. N 3.
Moisture-condensation type	Measurement of low dewpoints of industrial gases	0.001 to 3.0% of moisture. Dewpoints in range −110 to 100°F	1 to 3°F of dewpoint	Intermittent local readings. Most instruments not applicable to automatic control	Dewpoint is calculated from temperature and pressure measurement	E 17.
Electric resistance plus electrolyte dewpoint meter	Dewpoint measurement of air or gas streams	Dewpoints of −30°C to 60°C, for temperature range of −30 to 100°C	±0.5 to ±1.0°C of dewpoint	Remote indication and recording of dewpoint and ambient temperature. Automatic control can be provided	Response times of the order of 2 to 8 min. normally obtained. Relative humidity has to be estimated	F 10. N 3. P 4.
Dielectric constant type	Moisture in granular crystalline solids, liquids and gases	0 to 100% moisture	±0.5 to ±2	Remote recording and automatic control possible. Some types provide alarms	Fast response. Several sub-ranges required to cover whole of range. Temperature up to 160°C tolerated	F 3. L 1. S 4. T 5.
Nuclear magnetic resonance spectrometer	Moisture content of powdered and granular solids, viscous liquids and pastes	2 to 100% moisture	±2 or better	Intermittent detection only. Has possibilities for continuous measurement	Determination takes up to ¼ min. Determination accuracy influenced by paramagnetic components	B 5. F 1.

MEASURED OR CONTROLLED VARIABLE: OXYGEN CONCENTRATION

Type of measuring instrument	*Application*	*Range of instrument will fall within stated limits*	*Accuracy to within given percentage of full scale range*	*Suitability for automatic control and/or remote indication*	*Remarks*	*Maker or supplier*
Paramagnetic "magnetic wind" type	Measurement of O_2 concentration in gases in combustion processes; in nitrogen from air distillation plants	0 to 100% O_2	0.05 to 1	Can be used with recorder or controller	Inlet gas temperature should not exceed 60°C.	C 1, K 3.
Paramagnetic suspended element in non-uniform magnetic field	Measurement of oxygen concentration	0 to 100%	0.1 to 1	Can be used to set electrically-operated controller	Null-balance system. Not affected by conductivity variations	S 5.
Thermal conductivity	High oxygen concentration in gases; e.g., purity of oxygen from air separation plants	0 to 100%	2 to 4	Can be used for remote indication	Application and range depends upon thermal conductivities of other gases present	C 1.
Temperature rise measurement through catalytic chemical combination	Measurement of small concentrations in most gases, H_2, CO_2, and saturated hydrocarbons	0.001 to 0.75	±2	Can be used for remote indication	Slow response	E 11.
O_2 adsorption in galvanic cell	Detection of very small concentrations in gases; e.g., in nuclear energy field	0 to 100 ppm by volume	±5	Recording and control possible	Two-and-a-quarter minutes required for 90% of full-scale range to be indicated	E 11.

MEASURED OR CONTROLLED VARIABLE: PRESSURE

Type or primary measuring element	*Application*	*Instrument will have range within stated limits*	*Accuracy as a percentage of full scale reading*	*Suitability for remote reading, recording and automatic control*	*Remarks*	*Maker or supplier*
Bourdon tube	Most clean and non-corrosive gases and liquids	0 to 100,000 psig 0 to 30 in. Hg. vac.	±½ to ±1	Usually used for local reading. Electrical contacts can provide on-off control. Also used in some automatic control and remote indicating systems	Often the upper part of scale only is required. The lower 50% is then suppressed. Must be protected for high temperatures	A 8, 11. B 1, 2, 12. C 6. D 3. F 3, 7, 10. H 7, 10. K 1, 3. N 3, 4. P 3. S 1, 9, 11, 13. T 1, 8, 9. W 1, 4.
Bourdon tube with flexible seal	Viscous, corrosive or liquids depositing solids	300 to 15,000 psig	±½ to ±1	do.	Seals may be obtained in various materials, e.g., Fluon	A 11. B 12. N 3. P 3. S 1. T 1. W 1.
Diaphragm	Corrosive fluids, molten metals, asphalt, sludges, pressure or coarse vacuum	6 mm. Hg. abs. to 600 psi. Some transmitters allow max. pressure up to 5000 psi	±½ to ±1	Local and, if diaphragm is primary element of transmitter, for remote reading, recording and automatic control	More sensitive than Bourdon tube types. Temperatures up to 300°C or more permissible	A 8. B 1, 6, 12. D 6. E 10, 16. F 3, 5, 7, 10. I 2. K 1, 2, 3. P 3. S 1, 9, 11, 14. T 1.
Mercury manometer	Gases at moderate pressures	0 to 450 in. H_2O	±½ to ±1	Some mercury float types allow remote reading, recording and automatic control	Limited by height of mercury column permitted by instrument	B 6. H 9. K 3. N 3. W 5.
Mercuryless manometer, e.g., aneroid	Pressure measurement of hazardous fluids, e.g., high octane petrol, butadiene	0 to 600 in. water	±1	Suitable remote reading, recording, and readily linked to auto-automatic control system	Useful in ranges covered by mercury manometer types but where pressure of mercury undesirable	B 7. E 10. F 10. K 3. S 11. T 1.

Measured or Controlled Variable: Pressure, cont.

Type or primary measuring element	*Application*	*Instrument will have range within stated limits*	*Accuracy as a percentage of full scale reading*	*Suitability for remote reading, recording and automatic control*	*Remarks*	*Maker or supplier*
Bellows	Low pressures of vapours, gases, hot corrosive liquids	0 to 25 psig	±0.5 to ±1	do.	More sensitive than Bourdon tube types. Transmitters available capable of measuring pressures up to 150 psi, sensitive to 0.2 in. water, suitable for temperatures up to 600°F	B 6. E 4, 10, 16. F 7, 10. G 2. H 5, 7. P 3. S 1, 11. T 1, 8.
Capsule	Corrosive liquids and gases over short spans and where high accuracy desired	0 to 7000 psig (0 to 15 psig for some types)	±0.1 to ±0.3	do.	More sensitive than bellows	B 12. K 1. N 3. P 3. S 11. T 1.
Capsule servo-operated	Low pressures such as at boiler furnaces, kilns, steel furnaces	0 to 0.2 in. water	±1	Suitable remote reading, recording and readily linked to automatic control system	High accuracy under difficult industrial conditions	N 3.
Ring balance manometer	Draught pressures in boiler furnaces, gases in pipelines, etc.	0 to 30 in. water	±1	do.	Avoids need for pressure-tight shaft. Rather bulky. Used also for differential pressure measurement	E 4. K 3.
Inverted bell manometer	For low pressures also pipelines, carrying low pressure gases	−1.0 to 5 in. water	±1	Suitable for remote indication recording and automatic control	Ranges with spans as low as 0.10 in. water available	B 1, 6. D 4. E 4. F 10. H 5. S 14. T 1.
Transducers using strain gauges, Bourdon tubes and other means of converting pressure into a deduced signal	Steady or rapidly fluctuating pressures in corrosive atmospheres and fluids	0 to 50,000 psig	±0.5 to ±1	Most types linked to remote recorders. Automatic control based upon transducer primary elements possible	Some models will tolerate temperatures in the range −350°F to 2000°F. Electric signal ensures fast response and possibility of transmitting signal over considerable distances	P.11

MEASURED OR CONTROLLED VARIABLE: ABSOLUTE PRESSURE

Type or primary measuring element	*Application*	*Instrument will have range within stated limits*	*Accuracy as a percentage of full scale reading*	*Suitability for remote reading, recording and automatic control*	*Remarks*	*Maker or Supplier*
Bellows (single or double)	For vacuum drying plants, steam condensers, vacuum stills, etc.	0 to 40 psia	±0.5 to ±1	Suitable remote indication, recording and automatic control. Usually by pneumatic means	Accurate down to about 5 mm. Hg. Can be supplied in short spans	B 6. E 4, 10, 16. F 7, 10. G 2. H 5, 7. P 3. S 1, 11. T 1, 8.
Force balance primary elements	For pressure measurement under corrosive conditions	30 to 1000 psia	±1	do.	Not suitable for vacuum conditions. Often used where measurement is required for calculations by computer	B 1, 6. E 4, 10. F 10. H 5. S 11.
Aneroid	Low-pressure conditions	0 to 500 in. water absolute	±1	Readily linked to remote indicating, recording and automatic control systems	This type is compensated for barometric changes. Accurate down to 5 to 10% of lower end of range for low pressure ranges	S 11. T 1.

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MEASURED OR CONTROLLED VARIABLE: DENSITY OR SPECIFIC GRAVITY (LIQUID)

Type of measuring instrument	*Application*	*Range of instrument or control system falls within the stated limits*	*Accuracy as a percentage of full scale range*	*Suitability for remote indication and automatic control*	*Remarks*	*Maker or supplier*
Hydrometer types with or without inductance bridge	Continuous local measurement of liquid sp. gr.	0 to 3.5 sp gr.	3 to 4 decimal places of sp gr.	Inductance bridge types suitable for remote reading and automatic control	Not suitable for high-pressure applications or where solids present are likely to settle	E 4. F 6.
Chain balance float with transformer coil moving inside pick-up coil	do.	0.6 to 3.5 sp. gr.	2 to 3 decimal places of sp. gr.	Suitable for remote indication and automatic control	Some instruments of this type include temperature correction	B 6.
Continuous weighing of constant liquid volume	Density or specific gravity of slurries and corrosive solutions	0 to 2 sp. gr.	±1	do.	Reading can be expressed as solids mass per unit volume. Rate of flow in case of slurries must be fast enough to prevent deposition	P 7. R 4.
Differential bubbler types	Has been used for the measurement of sp. gr. of slurries, paints and viscous liquids	0 to 2 sp. gr.	±½ to ±1	do.	Not suitable for liquids which deposit crystals	B 6. D 4. K 1, 3. N 3. S 8, 11.
Differential liquid-purged pressure method	Used for continuous measurement and control of density in pulp and paper industry. Clay and lime slurries	0 to 3 sp. gr.	±1	do.	Suitable for measurement under pressure where pressure of liquid does not interfere with process stream	B 6. E 10, 16. F 10. K 3. T 1.
Nucleonic (gamma ray) fluid density type	Measurement of fluidised liquid and gas systems; e.g., pulverised coal feed to boilers	0 to 3.5 sp. gr.	±0.2	Remote reading and recording possible. Alarm signal can be given at predetermined point	Max. pipe diameter up to 36 in. Particularly suitable when access to fluid system is dangerous	E 2. I 5. L 11.
Buoyancy	Control of processes where completion indicated by density or sp. gr. Widely used in multi-effect evaporation plants in sugar industry	0.5 to 2.5. Oversize floats used for liquids of low sp. gr.	±0.5	Remote indication recording and control by pneumatic system	Will tolerate temperatures up to 900°F and pressures up to 3000 psig. Available in wide range of material	E 10. F 7. K 3.

MEASURED OR CONTROLLED VARIABLE: ABSOLUTE PRESSURE, (HIGH VACUUM)

Type or primary measuring element	*Application*	*Instrument will have range within stated limits*	*Accuracy as a percentage of full scale reading*	*Suitability for remote reading, recording and automatic control*	*Remarks*	*Maker or supplier*
Capsule servo-operated	Most industrial processes carried out at low absolute pressures	0 to 40 mm. Hg.	±1	Local reading. Can be arranged to form part of automatic control system	Accurate down to about 3 to 4 mm. Hg.	N 3.
Knudsen gauge	Pure pressure indication below about 10^{-4} mm. Hg.	6.10^{-6} to 1 mm. Hg.	1 to 10	Local reading only	Within a few per cent (less than 20) gauge response not dependent upon composition of gas. Not widely used: requires development	E 1. V 1.

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Measured or Controlled Variable: Absolute Pressure, (High Vacuum), cont.

Type or primary measuring element	*Application*	*Instrument will have range within stated limits*	*Accuracy as a percentage of full scale reading*	*Suitability for remote reading, recording and automatic control*	*Remarks*	*Maker or supplier*
McLeod gauge	Used as a standard for calibrating other instruments	10^{-5} to 7 mm. Hg.	2 to 4; falls to 10 at lower end of range	Local reading—intermittent	Tends to give low readings. At lower end of range accuracy falls off	E 1. P 6. V 1.
Thermocouple gauge	Leak testing of industrial equipment where high accuracy is not required	10^{-3} to 1 mm. Hg.	Accuracy falls from 2 to 4 to around 25 at lower end of range	Suitable continuous remote recording	Fast response. Must be calibrated for type of gas present and for operating temperatures	A 2. E 1. P 6. V 1.
Pirani gauge	Pressures below 1 mm. Hg. and for leak testing equipment	10^{-3} to 1 mm. Hg.	Accuracy falls from 2 to 3 to below 25 at lower end of range	Continuous remote reading	Gauge is composition dependent and therefore must be calibrated for composition and operating temperature	A 2. E 1. P 6. V 1.
Ionisation gauge	Usually used for low-pressure research. Useful for leak testing	10^{-9} to 10^{-3} mm. Hg.	1 to 2, better than 10 at lower end of range	do.	Hot filament types susceptible to attack by some gases Must be calibrated for accuracy to be realized	A 2. E 1. P 6. V 1.

INSTRUMENTS FOR PROCESS STREAM ANALYSIS

Type of primary detecting element or property measured	*Application*	*Range of instrument lies within stated limits*	*Accuracy as percentage of full scale reading or by other definition*	*Suitability for automatic control*	*Remarks*	*Makers*
Infra-red spectrometer, based upon comparison of sample spectrum with standard	Gases or solutions containing unsymmetrical molecules. Presence of catalyst poisons in gas streams of symmetrical molecules	400 ppm—100% of compound sought	±0.5 to ±2	Suitable; can operate either electrical or pneumatic systems	Clean sample required. Method requires knowledge of infra-red spectra of stream components. Not suitable for O_2, Cl_2, N_2 and other symmetrical molecules	I 2. P 2, 8. U 1.
Infra-red absorption analyser	Measurement of CO in streams of combustion gases. Control of solvent recovery processes	0 to 100% of component sought	±1 to ±2	Suitable	Sample must be clean, otherwise special standardising procedure necessary	I 2. P 2, 8.
Mass spectrometer.	Full continuous analysis of gases and liquids (including isotopes); e.g., analysis of hydrocarbon mixtures	For ions of mass numbers 2 to 1000; sensitive to 10 ppm	Mass number of ion to 1 part in 10^4	Remote reading and recording automatic control possible by means of servomechanism link.	Samples can be accepted at temperatures up to 300°C. Extreme speed of analysis provided	M 7.
Photometer. Light-absorption measures concentration by comparison with standard	Measurement of concentration where colour is a measure of component concentration; e.g., hydrogen in chlorine	Depends upon standard selected, e.g., for hydrogen in chlorine 0 to 20%	±0.5	Recording and automatic control possible with some designs	Flow cells can be provided in special materials for corrosive fluids	E 5. H 3. P 7. U 1.
Photometer for turbidity	Measurement of turbidities, faint or otherwise, of gases or liquids to show effectiveness of filtration and other mechanical separations	From 0.01 ppm upwards; minimum particle size 0.5 micron	±0.5	Recording and automatic control possible with some designs	Flow cells can be provided in special materials for corrosive fluids	E 5. H 3. P 7. U 1.

BCE 7071 for further information

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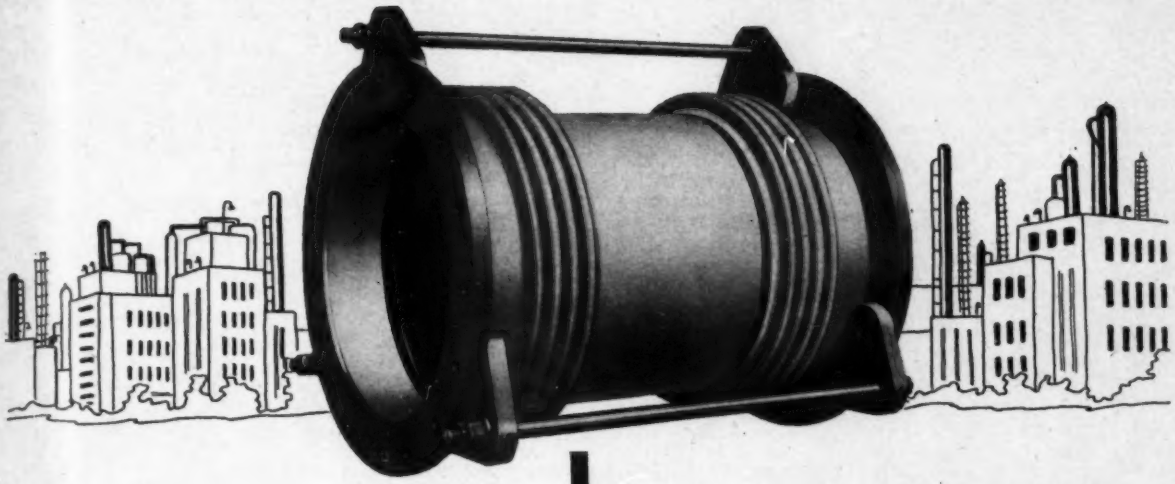
P4364

Instruments for Process Stream Analysis, cont.

Type of primary detecting element or property measured	*Application*	*Range of instrument lies within stated limits*	*Accuracy as percentage of full scale reading or by other definition*	*Suitability for automatic control*	*Remarks*	*Makers*
Gas chromatograph	Analysis of gas streams, e.g., hydrocarbon mixtures in the C_2 to C_5 range and liquids	0 to 100% sensitive to 1 ppm	±1 to ±2	Automatic control is possible with a memory device for each analysis	Instrument requires very little maintenance but gives results with less speed than other analysers. Sample requires vaporisation if a liquid	G 4. M 7. P 7, 8.
Photometer, U.V. absorption	Determination of Hg, benzene, toluene or xylene or other organic compounds with strong U.V. absorption in gases. Used at benzole recovery plants	0 to 6 gm/100 litres benzole for aromatics (Hanovia instrument)	±2 (as calibrated)	Continuous record obtainable derived from repetitive samples. Some instruments offer control functions	For accuracy must operate at stable, ambient temperature	E 5, 11.
Flame spectrophotometer	Simultaneous detection or estimation of Al, Ca, Ba, Li, Fe, K, Mg and other elements in solution. Estimation of Ca in presence of Sr	Minimum detectabilities vary: e.g., Al, 32 ppm; V, 0.2 ppm; K, 0.001 ppm; Na, 0.0001 ppm.	±1 to ±3 (often less than ±1). Accuracy depends upon concentration and complexity of sample	By modification of sampling arrangements can be made to operate as a continuous analyser	Rapid analyses provided. Time of determination depends upon sampling and sample preparation. For high accuracy concentration 10 to 100 times minimum detectable desirable	U 1.
X-ray spectrometer	Composition of liquids and solids; e.g., of Cu and Br in solutions, and ore concentrates	Elements of atomic number 19 to 100 up to 18 elements can be detected within this range, within concentration limits 50 ppm to 100%	±0.1	Results recorded remotely or by print-out tape. Can form part of automatic control loop	Time required per element is approx. 15 sec. analysis	S 10.
Refractometer, differential type	Clear gases or solutions where refractive index is a measure of concentration of a component; e.g., control of hydrogenation of fats and oils, concentration of sugar solutions	Difference of r.i. of 0 to 0.10	±0.1 of concentration in r.i. range 1.3 to 1.5	Remote recording, indication and automatic control possible either by electrical or pneumatic systems	Differential cells can be changed to give different ranges of refractive index. Limited to binary and some ternary systems. Solutions must be clear	H 3.
Refractometer measuring absolute refractive index	Measurement of concentration of liquid or gas streams	Concentration ranges 0.05 to 100%	Up to ±2	Local reading. Will give warning if concentration falls outside given limits	Limited mainly to binary systems	B 4.
Electrical conductivity (solution of gas)	Estimation of low concentration gases such as H_2S, NH_3, O_2, CO, CO_2. Effectiveness of absorption processes, etc.	10 to 100,000 ppm	±0.5 to ±2.0	Remote recording	Limited generally to binary systems	C 1. M 6.
Electrical conductivity (of solution of electrolyte)	For concentration of dissolved solids in a solution; e.g., in evaporation processes	1 ppm to 50% of dissolved solid	±0.2 to ±1	Remote reading, recording automatic on-off control possible by electric or pneumatic system	Cells can be constructed of special materials for corrosive solutions and will tolerate pressures approaching 100 atm.	C 1. P 4.
Thermal conductivity	Frequently used for CO_2 determination in flue gases. Also for NH_3, SO_2, H_2S in air, O_2 in N_2, H_2 in O_2 and other mixtures	0 to 100. For CO_2 range usually within 0 to 25	±2	Remote reading and recording. Some makes provide automatic control instruments	Limited generally to binary systems. Multi-point indication possible with some instruments	C 1. E 10. K 3.

BCE 7072 for further information

The use of **BELLOWS** in Chemical Engineering



Wherever pipes operate under conditions of temperature and pressure, expansion joints may be required. The bellows type expansion joint has in the past few years become standard equipment, being now recognised as extremely efficient. Teddington engineers have played a leading part in the introduction of stainless steel bellows expansion joints to the chemical industry and can be relied on to co-operate fully with design and plant engineers who are confronted with pipe problems.

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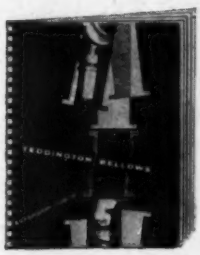

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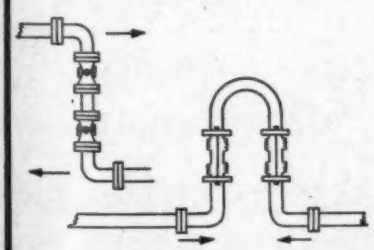

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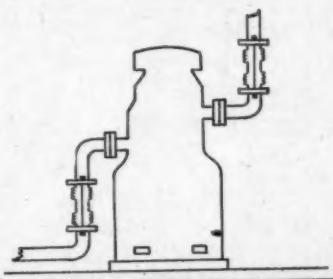

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Instruments for Process Stream Analysis, cont.

Type of primary detecting element or property measured	*Application*	*Range of instrument lies within stated limits*	*Accuracy as percentage of full scale reading or by other definition*	*Suitability for automatic control*	*Remarks*	*Maker*
Polarograph	Determination of composition of liquid streams such as effluents	Lower limit of concentration which can be monitored is 1 mg./l.	±1 to ±5	Automatic repetitive analyses continuously recorded	Time of determination usually varies from 2 to 5 min. for one constituent.	B 13. C 1. M 6.
*p*H meter	Composition measure by H-ion concentration; e.g., continuous determination of chlorides in aqueous paper extracts, in water supply and effluent treatment, continuous neutralising processes, cement manufacture	0 to 14 *p*H	±0.01 to ±0.02 *p*H	Remote recording at a single recorder from a number of electrodes. Automatic control by electric or pneumatic system	Various types of electrode available according to service; e.g., conditions of alkalinity, temperature and *p*H range. Some makes provide automatic temperature correction	C 1. D 5. E 7. K 3. M 3. P 4.

List of Instrument and Automatic Process Control Equipment Makers

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1. Adequate Weighers Ltd., Sutton, Surrey.
2. A.E.I. Instruments Division, Trafford Park, Manchester, and Rugby.
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L

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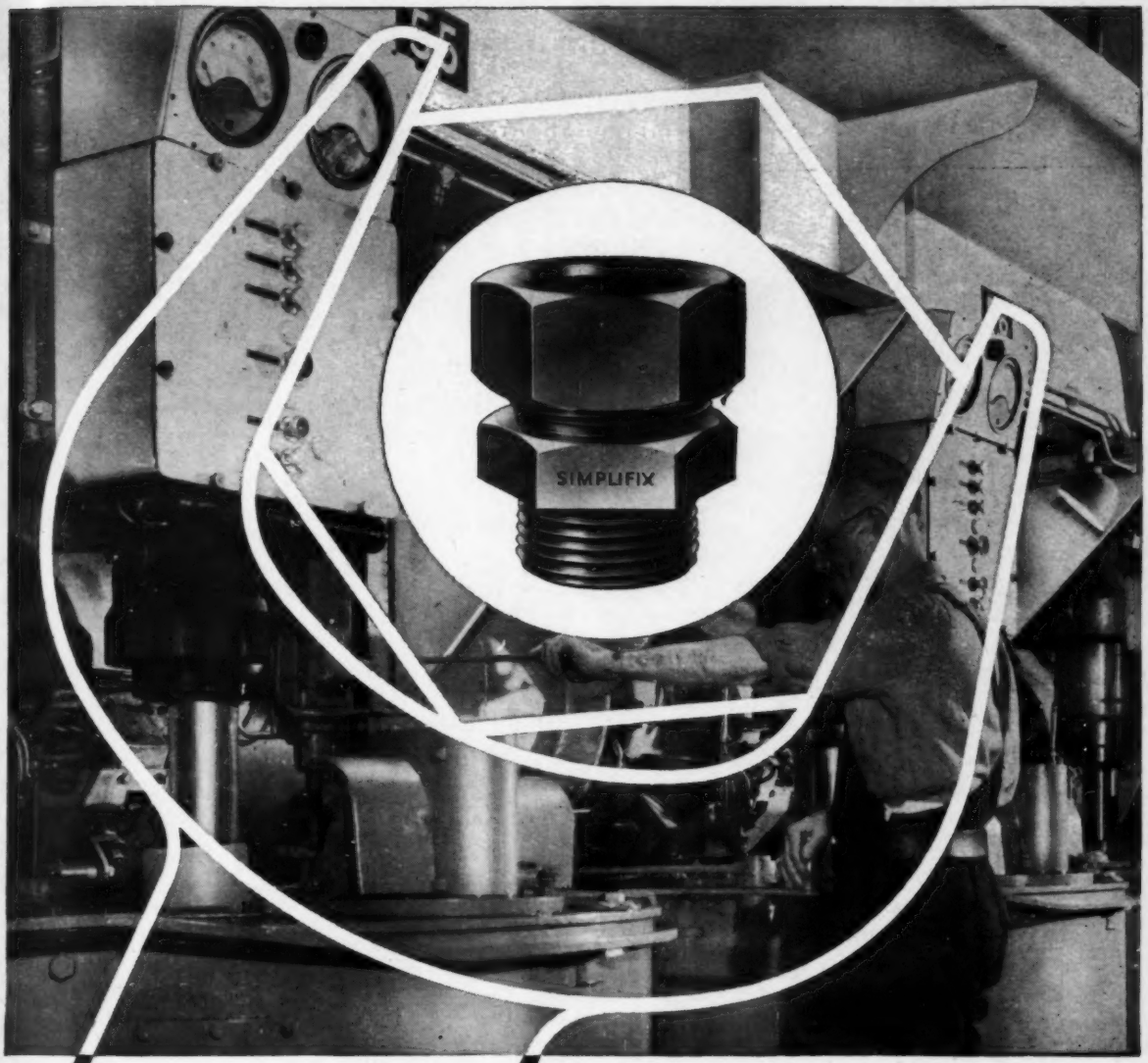

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NOMOGRAM SHOWING SURFACE AREAS OF TANKS AND DRUMS

by D. S. DAVIS*

* Head, Department of Pulp and Paper Technology, University of Alabama

When one plans to insulate a tower, tank or drum, he needs to know the total outer surface area. Such containers consist of cylindrical sections with two standard elliptical heads where the depth is one-quarter of the diameter. Petrarca[1] gives the formula for total outer area, A, as

$$A = \pi DL + 2.18\,D^2$$

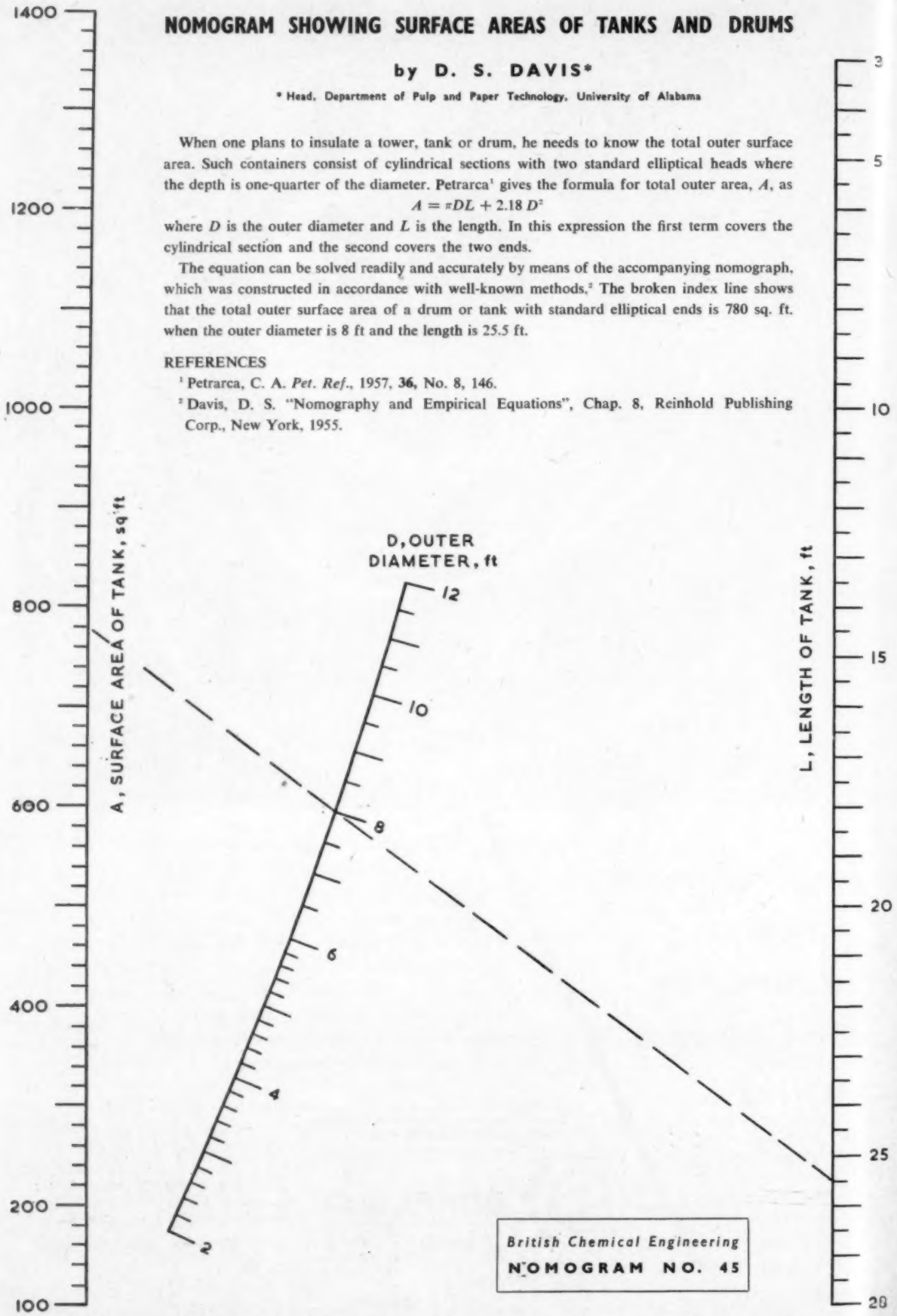
where D is the outer diameter and L is the length. In this expression the first term covers the cylindrical section and the second covers the two ends.

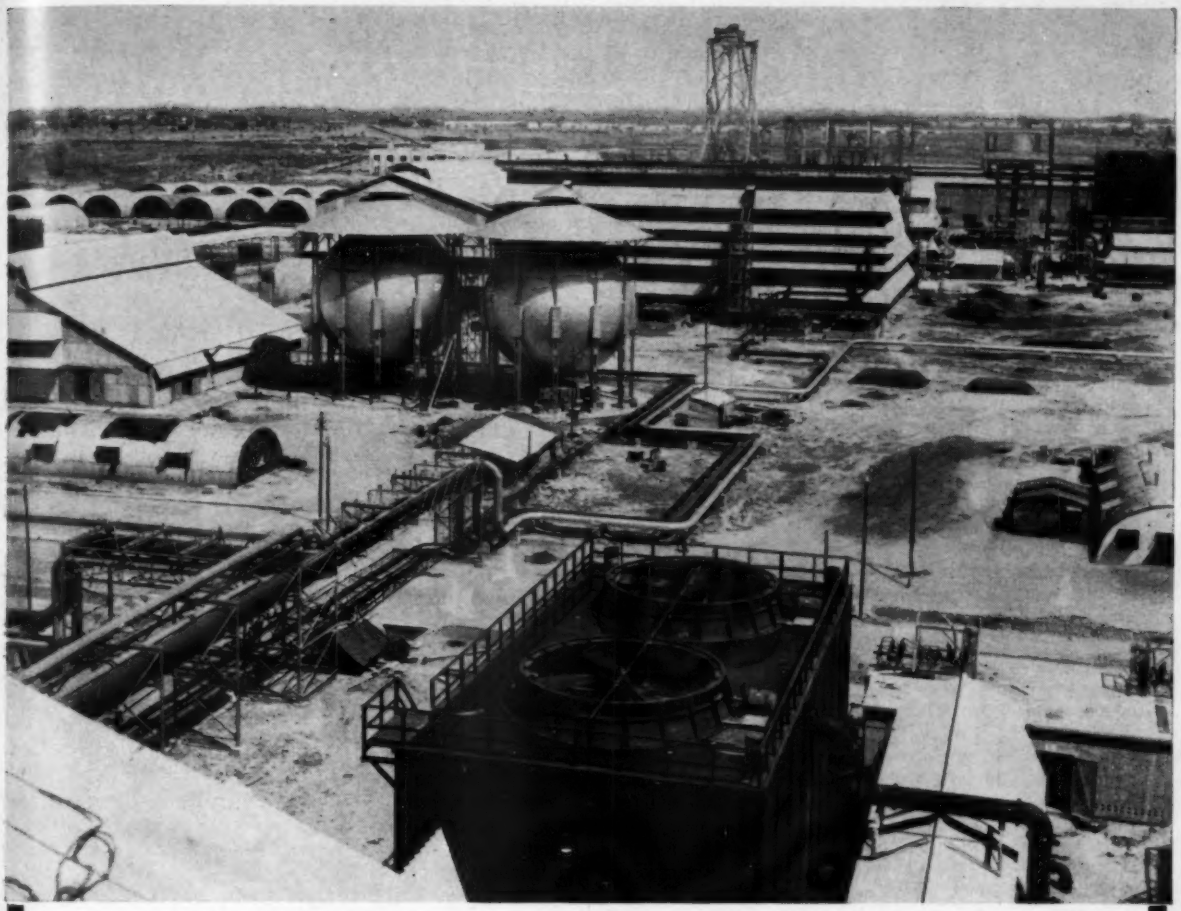
The equation can be solved readily and accurately by means of the accompanying nomograph, which was constructed in accordance with well-known methods.[2] The broken index line shows that the total outer surface area of a drum or tank with standard elliptical ends is 780 sq. ft. when the outer diameter is 8 ft and the length is 25.5 ft.

REFERENCES

[1] Petrarca, C. A. *Pet. Ref.*, 1957, **36**, No. 8, 146.

[2] Davis, D. S. "Nomography and Empirical Equations", Chap. 8, Reinhold Publishing Corp., New York, 1955.





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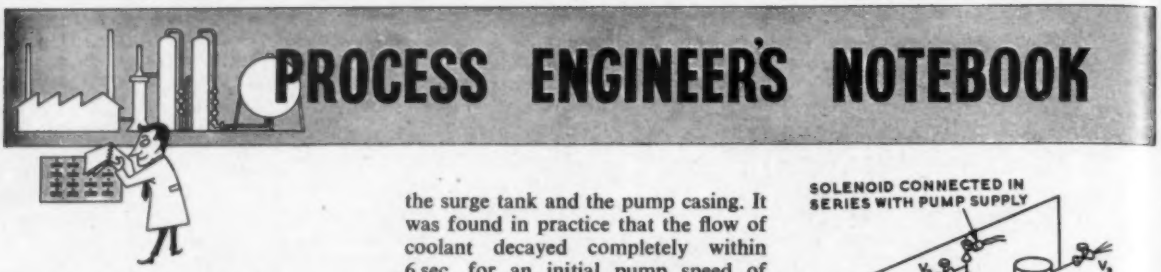
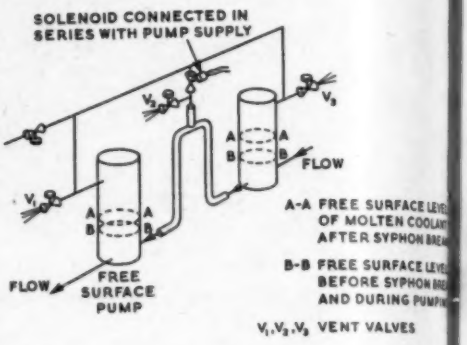


Trouble-free Quick-acting Valve

TO MEET THE NEED for a trouble-free, quick-acting valve in systems handling coolants—for example, molten metals such as sodium—trials were carried out on a simple siphon break device. The most effective and simplest method is shown in the diagram. The siphon is situated between a surge tank and free surface pump and all three are connected to a source of low-pressure cover gas such as nitrogen, the gas being at a pressure of 10 psig. Connection to the top of the siphon arm is made through a solenoid valve. This is connected electrically in series with the d.c. power supply to the motor driving the pump, so that when the main power supply is interrupted this valve opens automatically. The inert cover gas is then admitted and the flow of liquid interrupted, since the liquid within the siphon falls back into the surge tank and the pump casing. It was found in practice that the flow of coolant decayed completely within 6 sec. for an initial pump speed of 1000 rpm and for a Reynolds number of 2×10^5 at 940°F; and in 7 sec. when the pump speed was 1500 rpm corresponding to a fluid Reynolds number of 3.5×10^5 at 940°F. The purpose of the siphon break in the work mentioned here was to interrupt flow in low-pressure coolant systems, hence the low pressure of the cover gas used. But for other applications it may be practicable to use gas at a higher pressure.

In another trial stop valves were fitted in the lines connecting the inert gas supply to the pump tank and to the surge tank and the inert gas was at a higher pressure. The additional valves, in this case manually operated, were closed in preparation for the siphon break. This method did not, however, provide a quicker stoppage of flow than the simpler scheme shown in the sketch. This was probably because the maximum pressure of 12 psig above the siphon was only reached after some 30 sec. had elapsed.

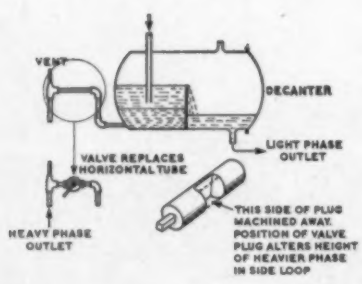

SOLENOID CONNECTED IN SERIES WITH PUMP SUPPLY
FLOW
FLOW
FREE SURFACE PUMP
A-A FREE SURFACE LEVEL OF MOLTEN COOLANT AFTER SYPHON BREAK
B-B FREE SURFACE LEVEL BEFORE SYPHON BREAK AND DURING PUMPING
V1,V2,V3 VENT VALVES

In this system, too, the action of breaking the siphon was accompanied by a reversal of flow of short duration. Improvements in the design of the cover gas admission system to give a steeper-time pressure characteristic would no doubt lead to an improved shut-off in the case of the modified system. Siphon priming is carried out by opening the valves in the side branches in order to release the cover gas from siphon, pump and surge vessel.

Reported by J. McDonald and W. Martin in North American Aviation Inc. Report (Atomics International) NAA-Sr-4050, October 15, 1959.

Modifications to Decanter

SATISFACTORY OPERATION was obtained with the decanter sketched here until leaks began to develop at the improvised swivel. Another disadvantage of the original swivel arrangements was that the vertical branch became too easy to move so that occasionally the operation of the decanter was upset. Alterations in the plant also made it necessary for the pipework leading from the decanter loop to be fixed rigidly in order to give satisfactory connections with storage vessels installed below the decanter.


VENT
DECANTER
LIGHT PHASE OUTLET
VALVE REPLACES HORIZONTAL TUBE
HEAVY PHASE OUTLET
THIS SIDE OF PLUG MACHINED AWAY. POSITION OF VALVE PLUG ALTERS HEIGHT OF HEAVIER PHASE IN SIDE LOOP

This meant that a means of height adjustment other than the movable loop had to be provided in order to maintain the correct balance between the head of liquid in the loop itself and the combined heads of the two phases in the separating part of the decanter. This was considered necessary despite correct calculation of the head of the heavier phase which fixed the approximate position of the loop height. The explanatory diagrams show how this problem was approached.

The short horizontal section of the loop was removed and replaced by a lubricated plug valve. A deliberately over-sized valve was chosen for the purpose. The plug was machined in the manner shown; e.g., one side around the port was milled away completely. The valve was then mounted with its plug horizontal so that the final height of the heavier phase could be adjusted by rotating the valve plug from its open position. To facilitate proper adjustment of the plug, a quadrant and pointer were clamped to the valve together with a stop to prevent complete closure.

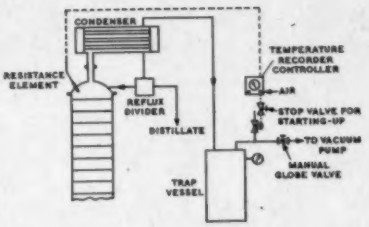
Twin-jacketed Vessel

IN THE BATCHWISE PREPARATION of some organic chemicals it is necessary in the early stages of a reactor to raise the temperature of the reactants before the desired reaction will occur. Thereafter, cooling has sometimes to be supplied in order to remove exothermic heat of reaction. One practice is to use a jacketed vessel with connections to enable either a cooling or heating medium to be passed through the jacket. This arrangement often requires a multiplicity of valves and suffers from the disadvantage, especially where steam is the heating medium, of a lag from the time the cooling medium is applied to the time the vessel contents begin to be cooled. A more flexible arrangement—admittedly a little more expensive than the vessel with a single jacket—is to have two jackets to the vessel, one for heating with just sufficient surface to raise the vessel contents in temperature within a reasonable period and the other of rather greater surface for the cooling system. A useful feature with this system is that it is possible to apply cooling to a vessel while heat is still being applied.

Control of Vacuum

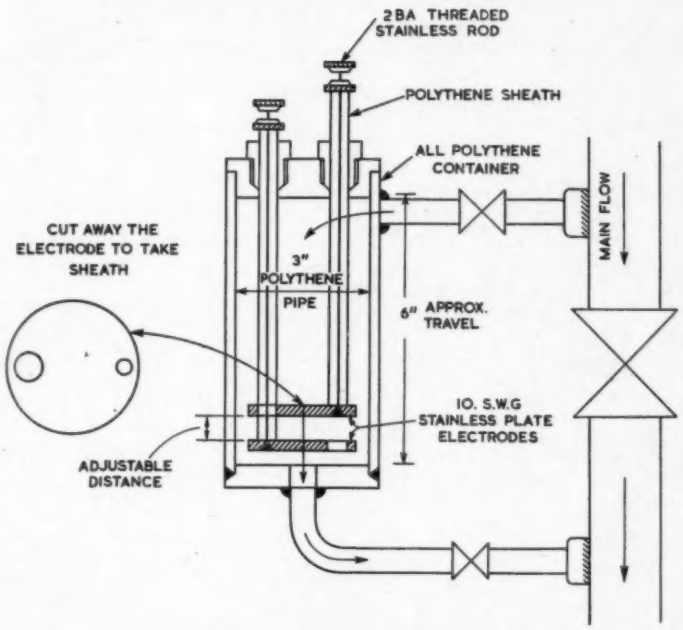
FOLLOWING MODIFICATIONS of a small-scale distillation plant for vacuum operation, the problem arose of finding a vacuum controller at short notice. One consequence of the alteration to the plant was that a spare resistance-type temperature sensing element and Wheatstone bridge type controller recorder had become available. Control functions from the latter were transmitted pneumatically. Fortunately, within the range of the detecting instrument fell the temperature at which the head product would condense at the required operating pressure. It was decided, therefore, to attempt to control the vacuum indirectly by means of the resistance element and controller. This seemed a safe practice. Since the accuracy of the measurement was of a high order ($\pm 0.2\%$), the vacuum was potentially controllable within very close limits; this proved to be the case in practice.

The controller was set to operate a small pneumatically-operated air leak

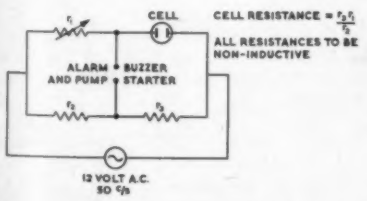


valve and the line to this valve was made as short as possible. The valve was fitted in a side branch of the main pipeline connecting the plant to a water ring vacuum pump. Coarse control of vacuum was provided by means of a globe valve (bellows-gland type). Fine control was left to the air leak. The resistance bulb was fitted into the top of the column at a point where condensation of the vapour upon the bulb was unlikely to occur and the controller was set to the temperature corresponding to the required vapour pressure of the condensate—in this case toluene. For pumping-down, the air line connecting the leak valve diaphragm motor was fitted with a small valve at the instrument panel and this was closed until the required absolute pressure (equal to the vapour pressure of the condensing toluene) was obtained. As soon as the temperature approached the normal operating figure, the valve on the panel was opened fully and the controller allowed to take over. The manual valve on the main line to the pump, once set, needed no further adjustment for a given operating vacuum.

Simple Safety Device for Condensate Return



IT IS FREQUENTLY NECESSARY for good thermal efficiency to return condensate from chemical processes to the boiler hot well. In the case in question, this condensate was from the closed steam coils of large soap kettles, the steam being at 100 psig.



This condensate was collected into a storage tank (small) with a float-operated starter for a centrifugal pump which delivered the condensate to the boiler hot well. Unfortunately, small leaks in the coils drew considerable amounts of caustic soda into the condensate and this resulted in an extremely high caustic alkalinity in the boiler on these occasions. The following simple alarm cell was fabricated in polythene, and with the help of some radio parts a simple Wheatstone bridge circuit was rigged up operating on the low-voltage a.c. supply The distance between the electrodes was adjusted to correspond to the toleration dose in the condensate. On exceeding this an alarm buzzer sounds, tripping the pump starter, thus allowing the condensate to overflow to drain. A similar system was found useful in dealing with the condensate from Karbate heat exchangers used to maintain the temperature of the electrolyte in a copper refinery.

F. MOLYNEUX

Contributions invited

THE EDITOR invites readers to submit, for possible publication in "Process Engineer's Notebook", notes on practical devices that have been elaborated on the job for improving the operation or increasing the safety of processes, or that have been extemporised in special circumstances. The contributions preferably should be of about 250-500 words, and be illustrated with a line diagram or sketch, or a photograph. A minimum of three guineas will be paid for each contribution used. They will be published anonymously or under the contributor's name, according to his wishes.

Book Reviews

Dynamics and Non-linear Mechanics
by E. Leimanis and N. Minorsky
Chapman & Hall, London, 1958, 206 pp., 62s.

THIS book is number two of the Surveys in Applied Mathematics in a series forming a joint project of the U.S. Office of Naval Research and *Applied Mathematics Reviews*, and consists of two monographs. The first monograph is entitled "Some recent advances in the dynamics of rigid bodies and celestial mechanics", and is by Leimanis, whilst the second is by Minorsky and is called "The theory of oscillations".

The object of the series of which this book is a part is stated by F. J. Weyl, Director of the Mathematical Sciences Division of the Office of Naval Research, to "have the primary objective of accounting in a summary fashion for the state of the fields which they cover, as determined by contributing developments at various times and in many places. The present articles are therefore aimed not so much at research specialists, actively contributing to the subjects discussed, as they are aimed at a broader, mathematically literate audience, looking for contemporary information on the important problems and results in these disciplines, whether be it for use in the classroom and seminar, or for the sake of possible application to problems in other fields of science and engineering, or simply for reasons of personal interest" (reviewer's summary). The main aspect of importance is that both these monographs deal very largely with the notable advances made by Russian workers, who, by the use of novel methods, have been able to solve problems which were previously intractable.

Leimanis's monograph is in two sections. The first portion deals with the dynamics of rigid bodies and with exterior ballistics. First, the rotation of a heavy body is considered, with reference to the cases of Euler and Poinsot, Lagrange and Poisson, and Kovlevskaya, amongst others. The Hess and Schiff equations are then discussed. The next chapter is on exterior ballistics, when the motion of a projectile is dealt with. Section 2, which follows, is on celestial mechanics, and the chapters in this section deal mainly with the three body problem. The importance of this contribution by Leimanis lies mainly in the applications to imperfect gyroscopes and rocketry. This first section of the book is mainly a summary, and requires considerable mathematical background to be understood, as detailed proofs and expositions of the theories are not given.

The portion on oscillations by Minorsky is almost the same length as the first part of the book, 88 pages against 108 pages. The field covered here is, however, rather narrower, which enables the author to be more generous in his exposition, so that this portion of the book is less concise than the first portion, and correspondingly makes less demands upon the initial knowledge of the reader. The introduction explains why the old method of differential equations is unsatisfactory for non-linear oscillations, and develops the new approach starting with the work of van der Pol. Chapter 2 deals with the two basic concepts of the new theory, and then goes into the theory of approximations. The third chapter deals with oscillations in systems which are nearly linear, mentioning such topics as synchronisation, non-linear resonance, and sub-harmonics. The last chapter is concerned with relaxation oscillations, with applications to the multivibrator, amongst others.

Both sections of the book contain many references, and there is no doubt that this volume will be found a very useful book of reference to reecnt work in the fields covered.

N. H. LANGTON

Brimstone: The Stone that Burns. The Story of the Frasch Process
by Williams Haynes
Van Nostrand, Princeton, New Jersey, U.S.A., 1959, 308 pp., 45s.

SCHOOLBOYS, far less informed than those postulated by Macaulay, know the Frasch process for the recovery of sulphur and can sketch with accuracy and aplomb the three concentric pipes sunk into the earth, with compressed air flowing down the centre one, hot water at about 100 psi (usually incorrectly shown as steam) in the outer annulus and molten sulphur of unexceptionable purity air lifted up the inner annulus to flash off its water and flow into gigantic vats to solidify. But even the initiated hardly suspect the difficulties, disappointments and physical hardships borne by Hermann Frasch, his associates and heirs, to bring this apparently transparently simple process into being and make it responsible for lifting out of the earth more than 130 million tons of sulphur and at the end of 1957 supplying 65% of the world's consumption of sulphur in all forms. In this book the story is told with journalistic style and pace, shorn of technical detail, but with inclusive skill so as to make the reader part of the action.

At the age of 25, inventing a process for the refining of paraffin wax, Frasch sold his process to J. D. Rockefeller and was encouraged by that man to set up as a petroleum consultant. This association with Rockefeller, and especially Frasch's invention of a method of desulphurisation of crude oil, permitted him to become rich and independent. Coming across Hewitt and Cooper mining for sulphur at Calcasieu, Louisiana, he offered them his process, and so the Union Sulphur Co. was born.

The development from that point of Frasch mining, its legal difficulties, fiscal setbacks and its swampy sites, to the sulphur shortage in 1950 and the opening up of the Mexican mines, to offshore mining at Grand Isle with hot sea water, is told in an interesting manner augmented with apt photographs and sketches.

Two misprints were spotted; at the bottom of page 19 the price of sulphuric acid is incorrectly stated by the omission of figures and on page 204 Fig. 9 is referred to as Fig. 8. On page 162 the implication seems to be that I.C.I. did not produce sulphuric acid from calcium sulphate until the 1950 sulphur shortage. I.C.I. were, of course, producing acid from anhydrite in the early 1930s. Mr. Williams Haynes' book makes good, light, inspiring and consoling reading for the chemical engineer depressed by his day's failure to make work an obviously sound process.

G.C.L.

SHORTER NOTICES

Water Research Association, Fourth Annual Report 1958-59, Redhill, Surrey.

The Director notes in this Report that this has been a rewarding year. The efforts of the Association to state in scientific terms the major technological problems of the industry have made possible the drawing up of the five-year research programme. The scientific judgment which the industry requires for the future includes that of the chemical engineer. Accumulation of basic information on chemical coagulation processes of water treatment, which is the Division's main activity, has continued. The study of the gas permeability of plastic pipes has been completed and the risk of the leaching out of stabilisers in plastic materials such as polyvinylchloride, by water flowing in these pipes, has been measured.

Five Years of Progress, National Industrial Fuel Efficiency Service, London. Fifth Survey with Report and Accounts for the Period April 1, 1958, to March 31, 1959.

The work of the Service in its fifth year has been more productive and more successful than ever before. At the beginning of the year, the bookings in hand were substantial and, month by month, the volume of new work secured has been consistently high. The total value of bookings made during 1958/9 was 31% greater than in the previous year.

Annual Reports on the Progress of Chemistry. Volume LV—1958, The Chemical Society, Burlington House, London, W.1., 1959, 527 pp., 40s.

As usual this volume is devoted to reviews of work in pure chemistry and may prove of limited interest to chemical engineers. Nevertheless, the section on kinetics of chemical changes may prove useful to designers and reduce the amount of searching for information on reactions.

Research Report of The Royal College of Science, London, 1956-1959.

This is the third of the triennial reports on the research work in progress in the Departments of the Royal College of Science. The Departments making up the Royal College of Science include Chemistry, Mathematics and Physics.

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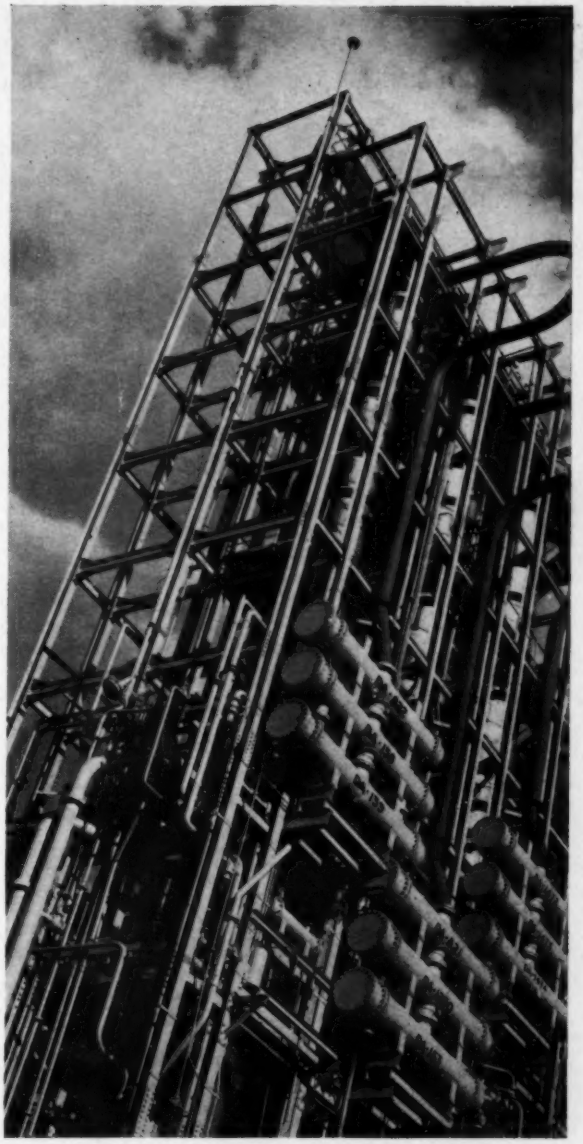

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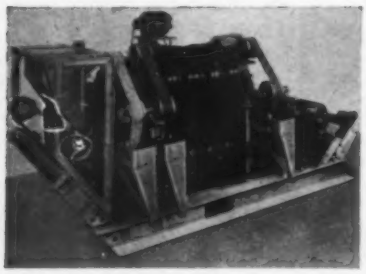
PLANT EQUIPMENT NEWS

Magnetic Separator

Two electro-magnets in a single magnetic circuit form the core of a high-intensity separator of the cross-belt type in which a conveyor belt takes the mineral from a feed hopper through air gaps between the poles of the magnets. Particles that are magnetic are attracted upwards and swept out of the magnetic field into collecting chutes by cross belts. Particles not affected by the magnetic field remain on the belt and are discharged into a chute under the tail pulley.

The current in the coils of the electro-magnets can be adjusted to give the flux density needed to lift the magnetic particles, and the spacing between each pair of poles can be set accurately and separately to suit the particular mineral to be recovered. The speed both of the feed belt and of the cross belts can be varied over a range that is wide enough to cover all separations. The capacity of the separator ranges roughly from 1 to 4 tons an hr according to the size and nature of the ore, being highest in general with coarse ores and decreasing as the particles become smaller.



Although designed to operate as a single unit, two or more machines can be linked together should there be more than one class of mineral to be recovered. Since each unit is regulated independently, the utmost use can be made of the power input available. The machine cannot, as a rule, be operated satisfactorily with ore coarser than about ¼ in. or finer than 50 mesh although both these limits have been exceeded in special circumstances. The feed must be quite dry. For effective separation it should be screened into fractions with the ratio of maximum to minimum diameters not exceeding about 4:1. The cross belts are made of thin, but tough, non-stretch nylon. **General Electric Co. Ltd., Fraser & Chalmers Engineering Works, Erith, Kent.**

BCE 7114 for further information

Dielectric-type Chromatographic Detector

A robust, flexible detector for use with chromatographs is based on measuring changes in dielectric constant. It is reported to be independent of the gas flow rate. Changes in the capacitance of a cell are converted into corresponding voltage fluctuations by means of an adjoining unit. The detector cell may work at or above the column temperature; owing to its unique design, and unlike a catharometer, it does not need to be thermostatically controlled. The converter assembly is thermally insulated from the cell and its temperature remains low even when the cell reaches its normal maximum working temperature of approximately 250°C. Sensitivity is claimed to be comparable with that of a catharometer. The method gives a uniquely positive signal with gases and has a very long linear range. The instrument also responds satisfactorily with liquids of low dielectric constant which are commonly used as solvents, such as benzene, cyclohexane, toluene and tetralin. **H. Tinsley & Co. Ltd., Werndee Hall, South Norwood, London, S.E.25.**

BCE 7115 for further information

Continuous Compounder-extruder

A combined unit has been made of an extrusion screw incorporated in the stirring shaft of a mixer so that final mixing and extrusion can be done directly in one single operation. The patented machine is claimed to be the most versatile one in existence. By the use of suitable heads, and in one single operation, compounds or "dry blends" can be prepared, i.e., granulating, colouring and drawing of tubes, bands, foils or cables can be covered. It can work with polyvinyl chloride of any type (emulsion or suspension polymer of any apparent specific gravity), cellulose acetates, polyethylene of any type, nylon and similar products, and any plastic material in powder, granule or flake form. The makers also state that it can handle any "dry blend" which cannot easily be extruded by means of the ordinary types of extruders, owing to the presence of oily and very slippery light components.

The mixing vat, which is also a loading hopper for the extruder, permits hot or cold mixing at atmospheric pressure or in a vacuum, intermittently or continuously. The unit can operate either on its own or in conjunction with another mixer. The mixing vat and the extruder screw can be easily cleaned in a few minutes by reversing the direction of rotation and by emptying the vat from the plug provided underneath. Thus the screw of the extruder, although removable, need not be withdrawn. A further claim is that this combined mixer and extruder is the only unit in existence which can operate its screws in reverse; any material obstructing the screws can thus be easily freed. In this way overloading and possible damage can be prevented and the reverse running can be used for mixing the charge in the mixing vat without extruding. This operation enables the work to be corrected if necessary; for example, by altering the composition or the temperature. **s.r.l. Ing. S. Pastorello, Via E. Breda, 118—Milan—Italy. Sole U.K. and Dominion Distributors: Industrial Plastics Ltd., 93 Regent Street, London, W.1.**

BCE 7116 for further information

Circulating Pump

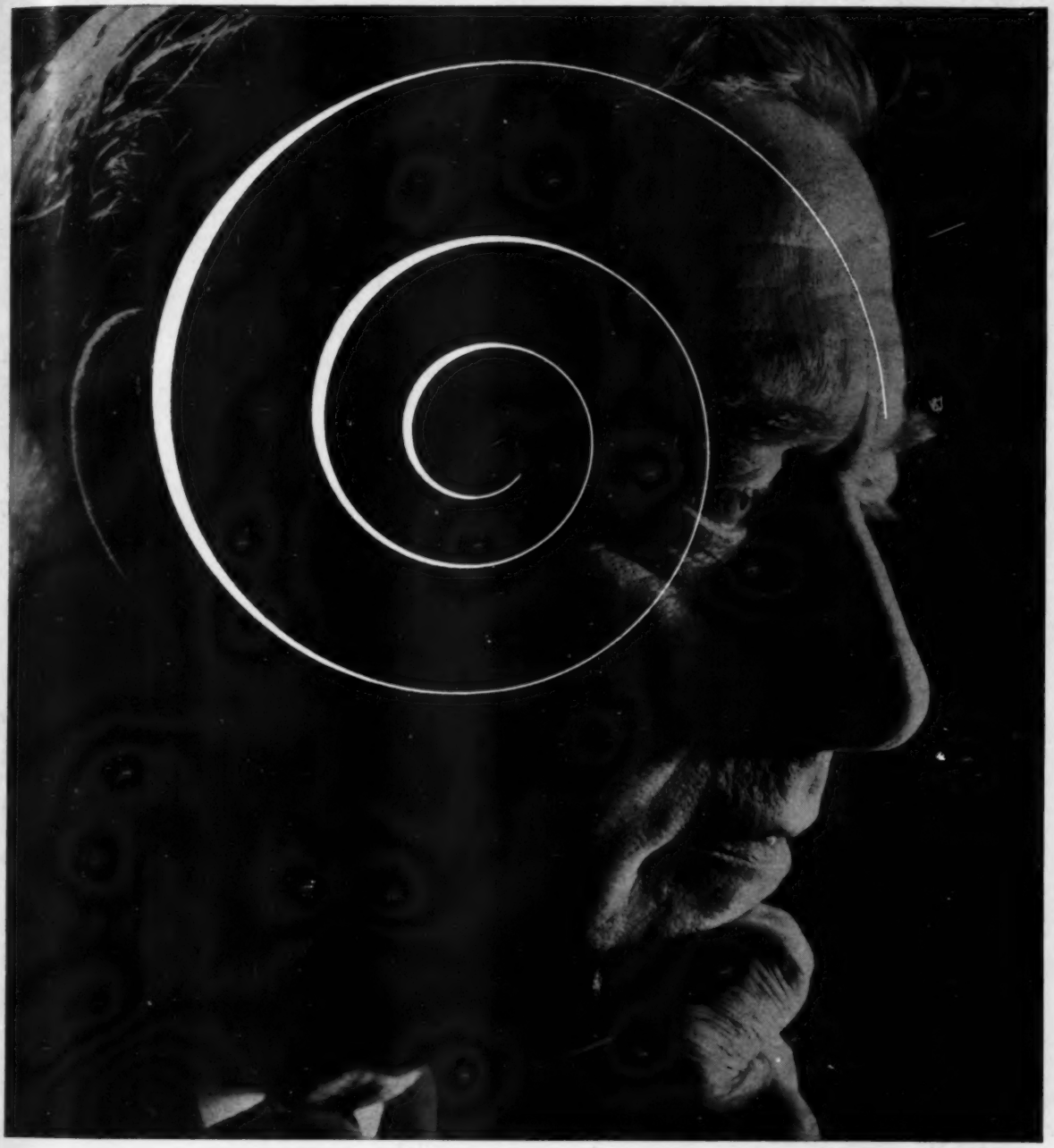
In forced-circulation heating systems radiators are connected together and to the source of hot water by small-bore pipes, generally of copper. Hot water is pumped through the system under pressure by a pump, such as the type illustrated. The pump is designed to be completely noiseless in operation and can run night and day. It is cheap and the smallest model takes only 45 watts. A "canned" rotor runs in the water being pumped and requires no lubrication. All internal parts are accessible from one side of the pump. All motors are wound for three-phase supply. Smaller units are designed for connection to single-phase supply of 200/250 volts 50 cycles by incorporating condensers. Special attention has been paid to good starting torque. Two condensers are connected, one for starting and one for running. The starting condenser cuts out automatically when the pump is running, leaving the other condenser to maintain correct phase balance. Kalorite pumps are available in various sizes, for duties from 1 to 160 gpm and for heads from 6 in. to 26 ft.

Harland Engineering Co. Ltd., Alloa, Scotland.

BCE 7117 for further information

Finned Heat Exchangers in Carbon

For air-cooling gas or liquids a finned heat exchanger has been developed and a patent applied for. It is built up of Diabon plates which have a number of raised fins to increase the surface. The finned plates are put together in the form of a comb so that serrated channels are



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PLANT EQUIPMENT NEWS

produced through which flows the cooling air. The liquid or gas to be cooled is then led through between two finned plates which are plane on their reverse sides. A plate, 1.8 m. long by 330 mm wide, has a total finned surface of 1.4 sq. m., and a finned plate heat exchanger built up of these plates might, for example, have a surface of 350 sq. m. The finned heat exchanger surface is not greater than 1.8 m. long, 2 m. high and 1.65 m. wide. It is therefore of special advantage where there is only limited space.

The advantage is, however, not only in the large surface but—as in general with Diabon—in the high conductivity and the universal resistance to corrosion. Due to the compact style of construction, there is also a pressure loss which is so small that it can be overcome with an ordinary centrifugal blower. This equipment was recently constructed for the first time for the Badische Anilin & Soda-Fabrik A.G. in Ludwigshafen/Rhein and in a slightly different form for an Italian firm. **Siemens-Plania, Chemische Fabrik Griesheim, Germany.**

BCE 7118 for further information

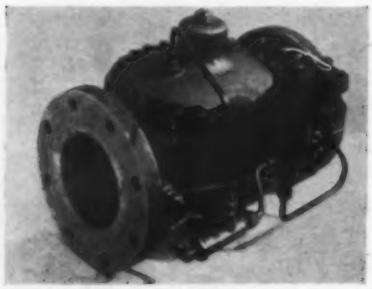
Hopper Level Switch

A hopper level switch designed to operate electrical contacts when bulk materials press against the diaphragm has been announced by Londex. The switch can be used for controlling the level in a hopper or similar container or, alternatively, for indicating the height of material by controlling signal lamps or an audible warning device. It is for use with any free-flowing granular or powdered material such as grain, flour, sand, etc. The hopper level switch is made in two forms, Standard (model STA) and Sensitive (model SEN); both units are identical in outline, the choice depending on the bulk density of the material. In addition, both models incorporate an internal adjustment enabling the sensitivity to be varied. Further information from **Londex Ltd., Anerley Works, London, S.E.20.**

BCE 7119 for further information

Solenoid-operated Stop Valve

A solenoid-operated valve for installation in liquid-carrying pipelines has been marketed by Simmonds Aerocessories Ltd. The purpose of the valve is to start or stop the flow of liquid in a pipeline by the make or break of the electric supply current. The valve may be used as a remotely-controlled stop valve. One important application of such a valve is its closure to keep a pipeline full of liquid in the event of current failure to the motor driving the pumps. The stop valve is available for operation from d.c. or a.c. supplies, and both flameproof and non-flameproof versions are available. At present it can be supplied in 4-in. and 6-in. sizes, but soon a 2-in. valve will be marketed. The valve is normally manufactured from high-tensile aluminium alloy. A forged-steel version can also be supplied. **Simmonds Aerocessories Ltd., Treforest, Pontypridd, Glamorgan.**



BCE 7120 for further information

Vibrating Screens

Don Valley are making the well-known German "Westfal" resonant, vibrating and circular-movement screens for screening, dewatering and classifying. The resonant screens are tray types acting as conveyors and have, among other advantages, rugged construction, simple and accessible design with ease of installation, high screening capacity and low power consumption. They are resiliently mounted on a balancing frame by rubber buffers and "Lignostone" laths. Drive is by roller bearings and eccentric, elastically coupled to the screens. The balancing frame is suitably weighted and buffered to prevent transmission of vibrations to the supporting structure. Screen widths are 2 ft 6 in. to 8 ft and lengths from 8 to 20 ft. Coke can be classified up to 500 tons/hr. The circular-movement screens have their vibration imparted by a rotating eccentrically weighted drive attached to the screen and are mounted on springs. Screen widths are 2 ft 6 in. to 6 ft and lengths from 8 ft to 14 ft 9 in. Capacities are up to 600 tons/hr with feed sizes up to 30 in. The vibrating screens are of simple and inexpensive design, suitable for small or medium duty up to 100 tons/hr and size up to 3 in. **Don Valley Engineering Co. Ltd., Wheatley Lane, Doncaster.**

BCE 7121 for further information

Transistorised Recorder

The Fielden Capacipoise Servograph is a compact, servo-operated recorder available in a.c. or d.c. current ranges. It has been designed to fit into the Capacipoise range of instruments, all of which operate from a supply of 12 volts d.c., but two models are available, one requiring an external d.c. supply and the other incorporating its own power pack. The latter may be operated from the normal 240 volts 50 cycles mains supply.

The size of the instrument has been chosen to give a chart 6¼ in. in diam. which is large enough for the vast majority of applications, whilst the recorder itself will occupy a minimum of panel space. All instruments are fitted as standard with a central indicating pointer moving over an arc of 300 degrees. The indicator scale length is approximately 15 in. and is readable from a considerable distance. One or two electrical contacts, which can be used for alarm or control purposes, can be fitted and other forms of control are also available.

The Servograph can record any current or voltage normally indicated on a meter and is quite suitable for recording the output of other electronic or electrical equipment such as *p*H meters, smoke density detectors, CO_2 indicators, beta gauges, tachometers, etc. The minimum full-scale deflection is 25 μA or 30 mV. Full details are available in Specification Sheet CAP. 2, which will be forwarded on request to **Fielden Electronics Ltd., Paston Road, Wythenshawe, Manchester, 22.**

BCE 7122 for further information

Small Mechanical Lubricating Pumps

Latest addition to the Pilgrim range of small mechanical lubricating pumps is the PW-313, designed primarily to run at low speeds. At 200 rpm it takes 7½ hr to deliver 1 cc of oil from each of the two delivery pipes. Both deliveries are fitted with separate plungers, and at 200 rpm each plunger operates once every ½ hr, displacing 0.066 cc of oil delivered during a 15-min. period. In order to achieve this delivery, the pump is fitted with a gear ratio of 6000:1. By adjustment of the control screws, each delivery can be varied independently from 0.066 cc down to nil. The pump operates equally efficiently up to 3000 rpm, the deliveries and times being scaled up proportionately. **The Pilgrims Way Motor Co. Ltd., Farnham, Surrey.**

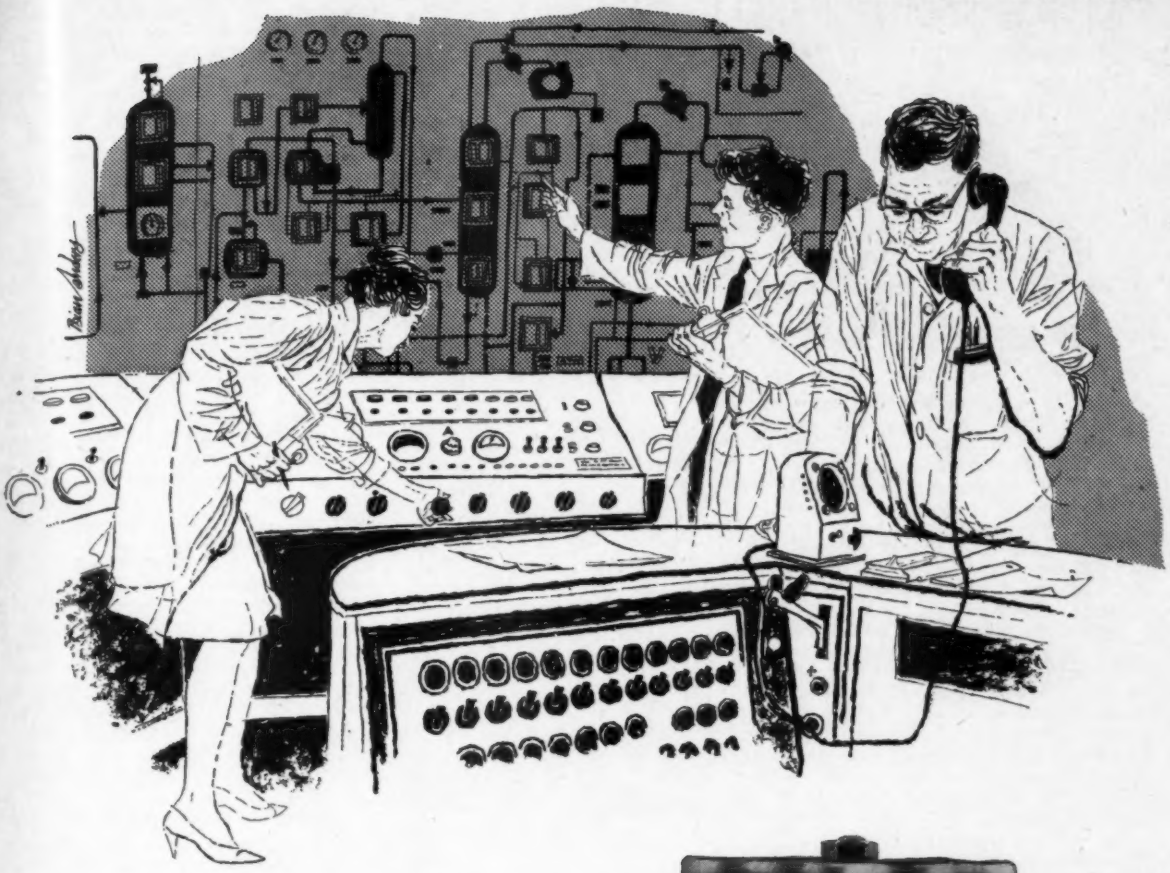
BCE 7123 for further information

Squeegee Pump

This pump is a positive-displacement feeder, using an open flexible tube of 1½, 2 or 3 in. diam. The tube is collapsed locally by four rollers which successively traverse it, from the stock intake point to the stock delivery point. Immediately after this point, compressed air is injected and conveys the material along the tube. Because of the squeezing action of the rollers, the air can only travel in one direction and there is no danger of leakage or blow-back.

Throughputs on materials which have so far been handled are as much as four tons per hour. Lifts of up to 70 ft and pipeline conveying lengths of 200 ft are well within the capabilities of this pump. Capacity can be stepped-up by increasing the speed of the pump; that is, the speed

BCE 7078 for further information



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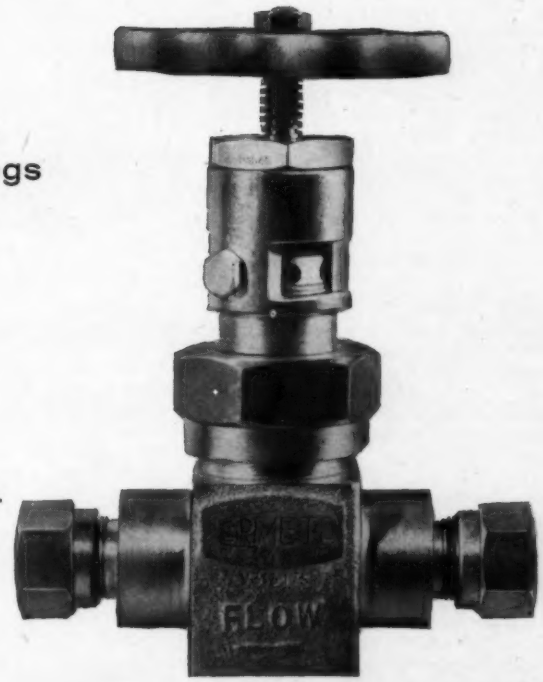


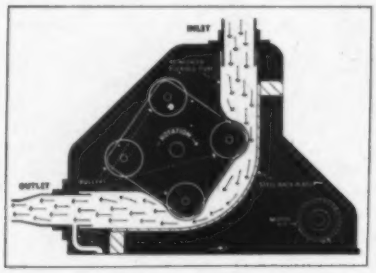
ERMETO

BRITISH ERMETO CORPORATION LTD

HARGRAVE ROAD · MAIDENHEAD · BERKS · TELEPHONE: MAIDENHEAD 5100

A member of the ALENCO Group of Companies

PLANT EQUIPMENT NEWS



at which the rollers traverse the flexible tube, but this is at the expense of the life of the tube. The tubes, however, are quickly and cheaply replaced; lives of over 1000 hr running can be expected from each tube.

The material for pumping has to be capable of being fluidised and most powders fall into this category. The pump will handle small lumps, say up to ¼ in., contained in small proportion in the bulk of the material. The pump is self-emptying and when changing from one product to another it is necessary only to flush the lines through with an increased amount of compressed air for a very short period. About 15 cfm at a pressure up to 5 psi is an adequate air supply for normal purposes. This is 1/10 of the air normally required by conventional pneumatic conveying systems.

The unit has several advantages over conventional pneumatic systems, such as low capital cost; low horse-power; negligible air volumes, therefore dust collection virtually eliminated; simple to install and requires little space; feed rate can fluctuate or run dry without damage occuring; and adaptable-flexible or rigid tubing can be used for the conveying lines, e.g., plastic, rubber, aluminium, etc., **Henry Simon Ltd., Cheadle Heath, Stockport.**

BCE 7124 for further information

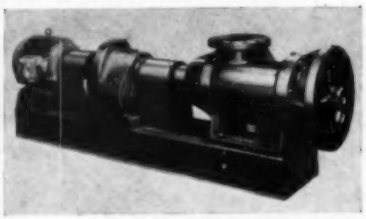
Flameless Welding for Thermoplastics

Gas-heated and electrically-heated torches are available for hot gas welding of thermoplastics using a filler rod normally of the same composition as the parent material. A gas such as nitrogen or compressed air is passed at low pressure (10-15 psi) through a heater element and leaves the torch through a nozzle. The temperature at the outlet measured at a distance of ¼ in. from the exit of the nozzle should be 280°C to 300°C, and the flow of welding gas 10-14 l per min., using a reducing valve in the line. In the gas-heated type the torch is fitted with a heat coil of stainless-steel tubing through which the welding gas is passed. The coil is surrounded by a heat-insulating shield to prevent thermal losses. The outlet of the heater coil connects to a welding nozzle which can be changed according to the thickness of the material to be welded. A patented feature of Rediweld torches is the baffle plate fitting over the injector which prevents blow-back when welding in an inverted position. Another patented feature is the collapsible torch support which can be lowered into position by depressing a stud fitted in the hand shield of the torch. The collapsible stand can be swung back and is then retained by a spring clip so that it does not impede the welding operation. It is possible to remove the collapsible stand altogether by spreading the two sides of the support at the point where it is hinged to the body. Each torch is supplied with two nozzles, one of ⅛ in. and one $\frac{5}{32}$ in. diameter. The weight of the Rediweld Model "A" torch is 18 oz. The heater gas used is acetylene.

The electrically heated type is wired to work from a 42-volt supply provided by a Rediweld transformer. The heater element can be replaced easily by unscrewing two retaining screws and lifting the insulating shield so that the element is exposed. This model also incorporates a patented support. The torch will work satisfactorily for a considerable time provided care is taken to pass either nitrogen or compressed air over the heater element before switching on. Mains-operated torches for 230 and 110 volts are also available. These are fitted with 500-watt heater elements, but otherwise the construction is the same as that of the 42-volt model. **Rediweld Ltd., 25-27 Kelvin Way, Crawley, Sussex.**

BCE 7125 for further information

Pump for Viscous Fluids



Reflecting the extending capabilities of pumps for handling near-solids and viscous fluids is a new screw pump. This machine is provided with an unusually large inlet port situated on a common axis with the screw impeller. This ensures an easy flow of material to the pump, which is particularly suitable for thixotropic fluids. Viscosities as high as 40,000 Redwood seconds are typical of some of the fluids this pump (known as the IMO) can handle. With such materials it is necessary to have a positive head over the suction. **Mirrlees (Engineers) Ltd., Hillington, Glasgow, S.W.2.**

BCE 7126 for further information

Plastic Valves and Tanks

The "Turbro" angle-type screw-down valves are made by Turner & Brown in either normal or high-impact p.v.c. Salient features are: square section thread on operating stem; a movable seat which is free and mounted on a ball joint so as to be self-aligning; "O" rings which are used as a rolling seal on the stem of the valve and as a seal under the bonnet. Plain socket or screwed ends are normally supplied, but flanges and backing rings can be supplied extra. Sizes range from ½ in. up to 3-in. bore. Valethene tanks, for which Turner & Brown are distributors, are moulded from seamless high-pressure polythene, either in standard cylindrical sizes ranging from 50 to 250 gal. or to customers' specifications. **Turner & Brown Ltd., Davenport Works, Bolton.**

BCE 7127 for further information

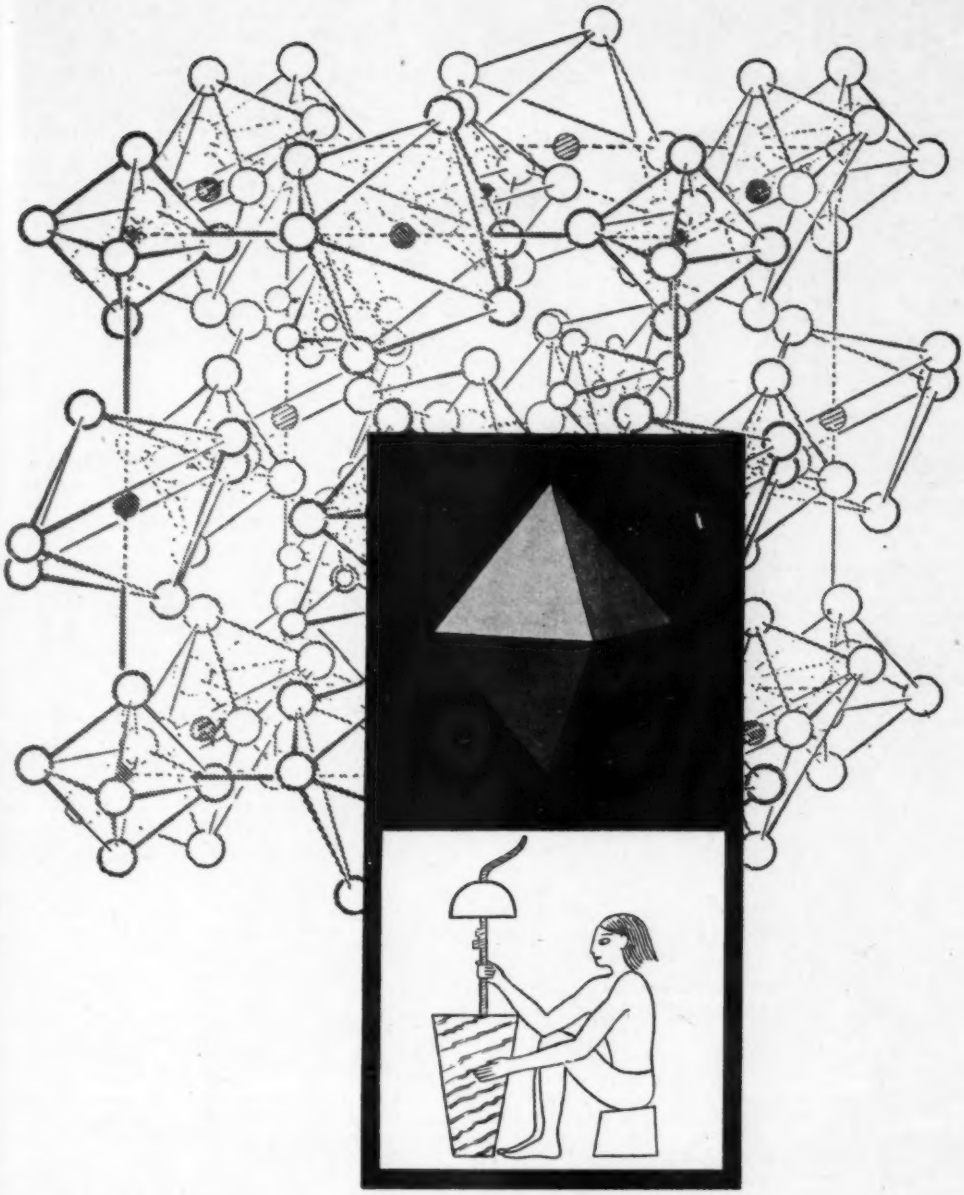
Metal Laboratory Furniture Units

All-metal unit furniture of improved appearance and durability has been announced. To avoid the annoyance of projecting handles, pressed metal work has been incorporated in the new laboratory cupboards and drawers. A continuous flange offers finger-grip space over the full width of door and drawer; this gives the units an extremely clean and flush appearance. Special attention has also been given to the adjustment and alignment of the drawers by the use of a simple cam on the drawer track, which is easily accessible from the front of the unit; a rubber buffer on the track makes for quiet operation. The range makes available a choice of many materials and finishes. **Griffin & George (Laboratory Construction) Ltd., Ealing Road, Alperton, Wembley, Middlesex.**

BCE 7128 for further information

Nitrogen Purification Plant

Among the Birlec exhibits at the Physical Society Exhibition was an animated flow diagram of a new type of nitrogen purification plant for the provision of superpurity nitrogen. This diagram showed how commercial nitrogen from any source can be purified to meet the stringent requirements of new processes in the electrical, metallurgical and other industries which require considerable quantities of exceedingly pure nitrogen. The design concerned belongs to the group of plants developed by Birlec Ltd. to provide nitrogen and other industrial gases in the grades of purity required at economic prices. In the nitrogen purification plant, compressed commercial nitrogen, containing free oxygen, is passed over a bed of heated activated copper which removes the oxygen as copper oxide, the residual oxygen content being in the region of 10-20 ppm. At the same time, traces of carbon monoxide and hydrogen are removed. At suitable intervals the activated copper mass is reduced with hydrogen and re-used. To remove the majority of the carbon dioxide and water vapour present the nitrogen is passed, after cooling, through a vessel containing sodium hydroxide pellets. The plant design provides further reduction in the water vapour content to a dewpoint of −80°C by a molecular sieve adsorption unit. A Birlec molecular sieve dryer was exhibited on the stand. Removal of the remaining traces of oxygen, carbon dioxide and water vapour takes place in a reactor containing heated gettering



The earliest chemical industry

Alum has been manufactured by Spence for over 100 years. It is one of the oldest chemicals used by mankind; indeed there are references which go back 4,000 years. In addition to being one of the largest manufacturers of alum and aluminium sulphate for paper making and water purification Spence are also producers of catalysts for petroleum refining and organic titanium compounds for the paint, plastic and textile industries.

SPENCE

PETER SPENCE & SONS LTD., WIDNES, LANCS.
Also at London, Bristol and Glasgow.

PLANT EQUIPMENT NEWS

material. The complete process reduces the quantity of oxygen-containing constituents in the product nitrogen to the region of 10 ppm. **Birlec Ltd., Erdington, Birmingham, 24.**

BCE 7129 for further information

Air Filter

A new type of filter for compressed air is now available from Vokes Ltd. It is made in 10 models for pipeline sizes of ¼, ⅜ and ½ in. Two types of filtering element can be supplied according to the duty; thus one element is suitable for average concentrations of oil, grit and water in compressed air, whereas the other element finds application where a very high degree of air purity is desirable. **Vokes Ltd., Guildford, Surrey.**

BCE 7130 for further information

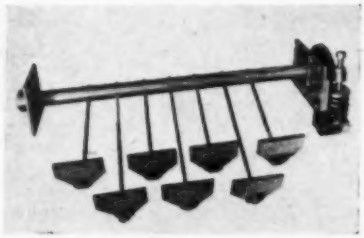
Pump with Centrifugal Action

A new self-priming liquid ring pump of unusual design can handle either liquids or gases or a combination of the two. The pump is readily primed (18 sec. for a 23-ft lift) and it will maintain its prime indefinitely. The pump is free from air-locking even when loops or leaks are present in the suction line. Foaming solutions and emulsions are both easily handled. The operating principle of the pump is simple. The centrifugal force of the pump's impeller separates the liquid from the lighter air which gathers at the centre of the impeller and casing. The liquid is then directed by centrifugal action toward the centre, pushing the air ahead of it and through the discharge. The impeller is hydraulically balanced and floats axially on the shaft. Maintenance is easy, since access is provided through a detachable casing cover so that it is not necessary to disturb the pipe connections. Capacity of this pump (Gould Fig. 2520) is up to 55 gpm, with heads in the vicinity of 40 ft. With closed discharge, heads approaching 90 ft are obtained. N.P.S.H. value at reduced capacity (8 gpm) is 7 ft and this increases to 25 ft for the maximum throughput. **Goulds Pumps Inc., Seneca Falls, New York.**

BCE 7131 for further information

New-type Scraper for Belt Conveyors

Richard Sutcliffe are making a multi-blade scraper for conveyor belts which has a number of advantages over the conventional type. The normal counter-weighted type does not react quickly to variations in belt line and wears excessively in the centre where the majority of the material adheres to the belt. If left long enough, the belt wears a slot of its own width in the scraper, thus being constricted by likelihood of damage. The multi-blade scraper overcomes all these problems. A glance at the illustration shows the arrangement. It consists of a number of small rubber-covered steel scrapers 5 in. in width mounted on bars from the main shaft so that the whole



width of the belt is scraped. The bars are of spring steel so that each little scraper can take up wear individually, tension being put on initially by rotating the main shaft. Maintenance is also easily undertaken. **Richard Sutcliffe Ltd., Kirkgate, Leeds, 1.**

BCE 7132 for further information

The Pye Process Analyser

This instrument, which is an industrial version of the well-tried Pye Argon Chromatograph, has been developed in association with I.C.I. Billingham Division. It is characterised by the high sensitivity and exceptional stability of the Argon Chromatograph, and full advantage has been taken of the extensive information obtained by I.C.I. Billingham Division in operating process analysers in a variety of chemical and petroleum industrial applications over a considerable period. The instrument automatically draws a sample from the process stream, analyses it by Argon Chromatography and presents the results on a recorder. A versatile control system selects and attenuates a number of individual peaks or gives a complete chromatogram. The equipment, which is suitable for use in hazardous areas, is completely flexible in application. Facilities which may be supplied for individual installations include dual column analysis, two-stream analysis, column switching, flow programming and others. **W. G. Pye & Co. Ltd., Cambridge.**

BCE 7133 for further information

Fast Digital Computer

This newly developed instrument is designed for recording digital information collected by electronic scalers without destroying the scaler indication. It is not an electrical typewriter, as it prints up to 14 characters simultaneously. It has

numerous applications, one of which will especially appeal to chemical engineers, is that it can be used for data logging. This service is provided when the printer is fitted with a tabulator, in which case 24 or more columns can be printed on a 600-mm roll. Further information from **Radiatron, 7 Sheen Park, Richmond, Surrey.**

BCE 7134 for further information

Smallest Miniature Potentiometer

The Plessey Co. Ltd., in response to the growing demand for miniaturised equipment, has introduced the Type L potentiometer—said to be the smallest of the spindle-operated type in production. Housed in an aluminium case, it is only 0.5 in. in diam. The L series, robustly constructed on the well-tried Plessey principle of moulded carbon tracks, incorporates a brush assembly of unique design. Two tracks are included in the moulding: a carbon, resistive outer and a silver-loaded, conductive inner. They are bridged by a single, tension-located brush housed in an insulated carrier. By reducing the number of pressure contacts, greater reliability is achieved. The L potentiometer operates within the temperature range −55°C to 85°C and has a voltage limitation of 350 volts. **The Plessey Co., Ltd., Ilford, Essex.**

BCE 7135 for further information

Polyester Self-adhesive Tapes

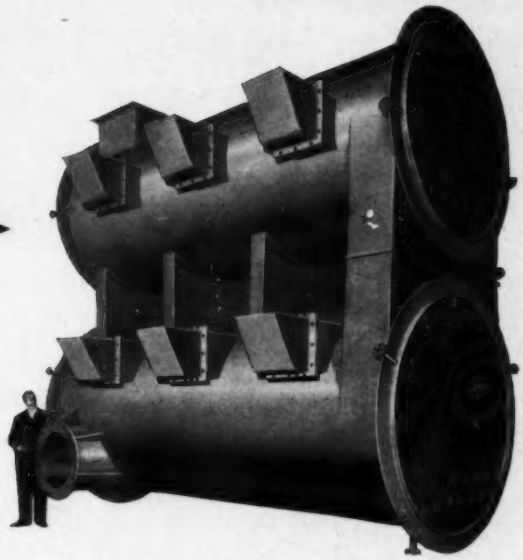
It is claimed that a new pressure-sensitive tape with a thermosetting adhesive overcomes the problem of deterioration when stored. Under normal storage conditions the tape is said to have a shelf life of six months or more. In use, once the adhesive is set it is no longer pressure sensitive and the tape therefore can be said to give a permanent bond. The film and the adhesive are then completely unaffected by temperatures of up to 180°C. This new tape has advantages in heat resistance and grip over those with thermoplastic or thermostable adhesives. Under heat, there is no softening of the adhesive, usually associated with loss of grip. It is available in 72-yd rolls, on 3-in. diam. cores, in a variety of widths ranging from ¼ in. upwards. The tape is said to have a high chemical resistance as well as thinness and flexibility. **Gordon & Gotch (Sellotape) Ltd., 8-10 Paul Street, London, E.C.2.**

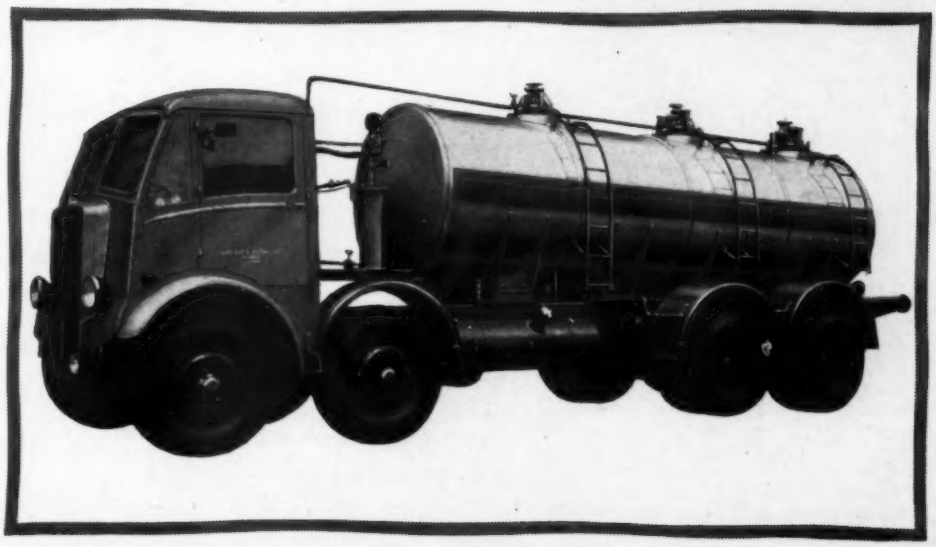
BCE 7136 for further information

Insulation Protection

Texolag insulation protection, which has been introduced by R. A. Brand & Co. Ltd., is a plastic coating system for preserving insulation materials on pipelines, storage tanks, reaction vessels and other types of process equipment. Texolag has been designed for the protection of insulation where vapour sealing and resistance to solvents or corrosive atmosphere is required. Continuous pipelines and regularly shaped vessels may be protected by using Texolag base, which consists of fabric impregnated with a plastic composition and is wrapped round the insulation surface over a coat of sealing

SPECIALISED FABRICATION





Widnes Foundry & Engineering Co. Ltd., offer a skilful, comprehensive service to industry, both in fabrication and foundry work. Two recent examples of fabrication are (top) mild steel casing, consisting of two shells, bottom shell 7 ft. 5 ins. dia. x 17 ft.; top shell 6 ft. 6 ins. dia. x 17 ft., and (below) one of three stainless steel road tanks for transporting phosphoric acid; each tank has three compartments, and is jacketed with aluminium. APPROVED BY LLOYDS FOR CLASS 11 WELDING FOR PRESSURE VESSELS.

WIDNES

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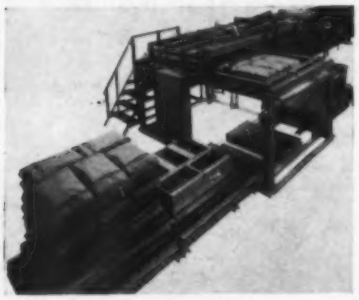
PLANT EQUIPMENT NEWS

compound and then sealed with a special lacquer. Irregularly shaped vessels, flanges and valves may be treated similarly or else a sprayable solution can be used to produce a continuous plastic film. The lacquer for sealing the system can be supplied pigmented to any colours and may therefore be employed for colour coding. Modern foamed plastic materials may also be protected. The system may be used on any equipment where the temperature of the external surface of the insulation does not exceed 160°F or fall below −30°F. It is said to be very resistant to spread of flame, thus reducing fire hazards. **R. A. Brand & Co. Ltd., Letchworth, Hertfordshire.**

BCE 7137 for further information

Automatic Pallet-loading Machines



Western Manufacturing are producing automatic pallet-loading machines which accurately load bags, cartons, etc., on to pallets, thus saving 50% storage space by higher stacking. Its speed is easily adjustable to suit a variable production rate. The machine takes sacks or containers from the production, and uniformly arranges them on the pallet to any desired pattern. This is repeated until the pallet is fully loaded. It is then ejected, ready for removal by fork-lift truck. Associated equipment can also be obtained such as a vibro-flattener for sacks, powered roller conveyors and empty pallet dispensers. **Materials Handling Division of Western Manufacturing (Reading) Ltd., Woodley, Reading.**

BCE 7138 for further information

Large Container Handling Equipment

Powell Duffryn are manufacturing an entire range of the American Dempster-Dumpster container handling vehicles and equipment which offer an economical method of materials handling or of refuse disposal. The "L.F.W." series of seven models will lift, transport and dump 6000 lb. to 50,000 lb. in containers of 1 to 15 cu. yd capacity. The "G.R.D." can handle the same containers, but can lift them into a rail wagon. The "Dumpmaster" has a body of either 18, 24 and 30 cu. yd capacity with hydraulic compaction. It can self-load from smaller containers. The "Dinosaur" can load or pick off its own body which can be constructed of 10 to 40 cu. yd capacity. All the machines are ruggedly constructed and have hydraulic-operated movements. **Powell Duffryn Ltd., Great Tower Street, London, E.C.3.**

BCE 7139 for further information

Reversing Motor Control Unit

The ElRemCo motor control unit from the Electric Remote Control Co. gives automatic reversal of rotation of electric motors or for any other applications where periodic and alternate operation of two electric circuits is required. The overall timing cycle can be anything between 10 sec. and 30 days. Three standard variations are: Type MCU/A which can be started and reset by push buttons; Type MCU/B which has no buttons; and Type MCU/S which is as MCU/A, but the overall timing period can be independently adjusted. All units have indicator lights and can switch 6 amps at 250 V a.c. Watertight or flameproof types can be supplied. **Electrical Remote Control Ltd., Harlow, Essex.**

BCE 7140 for further information

Vibrating Conveyors

The Ajax vibrating pan conveyor made by Acme Conveyors can handle a wide variety of materials, from 5-micron powder to large lumps with temperatures up to 350°F, by three basic types—open, closed and tubular pan. The design provides wide latitude in length, tonnage and in meeting sanitary, abrasive and explosive conditions, etc. Pans can be fitted with screens, water jackets and gates. Examples are quoted of operation in a vacuum and use as a feeder in an acetylene plant. The reciprocating drive unit is robust and enclosed and is fully balanced, except, of course, in the line of reciprocation. It is supported on spring-loaded arms, and fan widths range from 6 in. to 3 ft, giving capacities of 35,000 to 200,000 lb./hr based on 20-mesh material of 100 lb./ cu. ft bulk density. Operations such as washing can be arranged simultaneously with conveying screens, and vibrating tables for packing down material in containers can also be supplied. **Acme Conveyors Ltd., Walsall, Staffordshire.**

BCE 7141 for further information

Continuous Lining System

A thick, continuous lining system has been announced which has now stood up, in a large area, to three years of exposure to continuous high humidity of the order of 100% without sign of failure of any kind. The material, called Correnda, comprises a special formulated filler bonded with a vinyl type of material, finished with a plastic system of either an epoxy or polyester type, depending on the exposure and operating conditions. It is said to be able to withstand the most corrosive conditions likely to be encountered in industry. A complete lining is built up of the special plastic-based render, finished with a heavy-duty plastic coating that results in a very hard, tile-like, high-gloss finish available in a wide range of colours. **Corrosion Ltd., 16 Gloucester Place, Portman Square, London, W.1.**

BCE 7142 for further information

Packaged Oil-gas Plants

The Incandescent Heat Co. Ltd. report their development of a new process for the gasification of petroleum oil. The process is continuous and does not employ catalysts. Cracking heat is supplied by burning oil and waste products in a compact and simple furnace setting. The oil to be gasified is injected together with steam into a system which is specially designed to enable a uniform and precise control of cracking temperatures to be exercised. By these means the production of unwanted by-products (particularly carbon and tarry condensates) is said to be kept to a minimum; more particularly the calorific value of the gas produced can be varied continuously in the range 500 to over 1200 Btu/cu. ft. The gas is interchangeable with natural gas or coal gas of similar calorific value. Results obtained with a heavy distillate oil indicate that this system can be operated economically over a wide range of throughputs. **The Incandescent Heat Co. Ltd., Smethwick, England.**

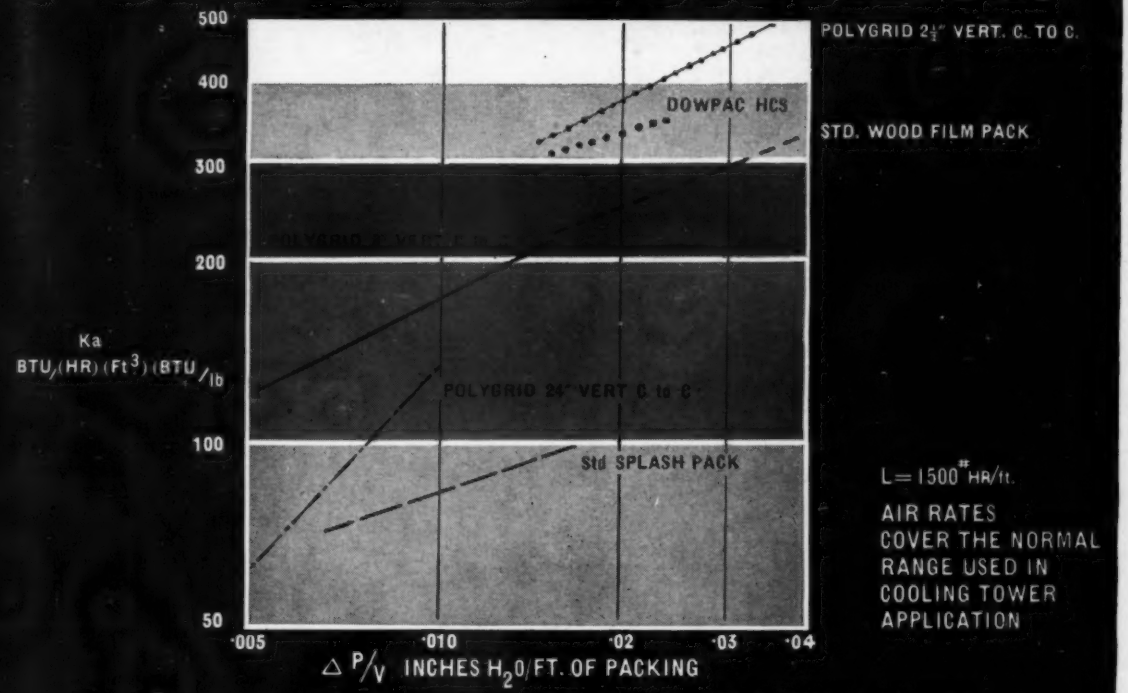
BCE 7143 for further information

Hydrostatic Tank Contents Gauge

A new pressure-bulb type, hydrostatic tank contents gauge, manufactured by Firth Cleveland Instruments Ltd., is said to measure the head of liquid in most types of non-pressurised tank wherever situated and regardless of size and height. Its indicator can be placed up to 250 ft from the tank to show by a dial and pointer, 4, 6, 8 or 12 in. in diam., either the depth of liquid or the tank contents. The gauge is completely self-operative and offers continuous indication.

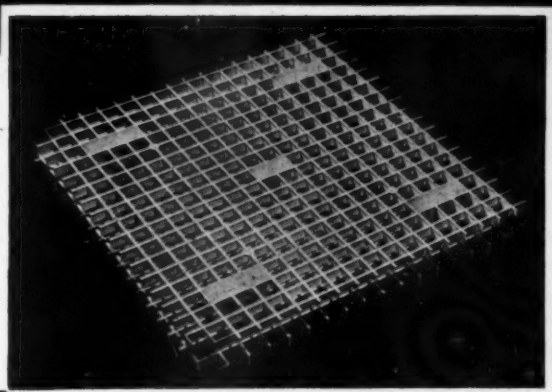
It is supplied as two units, transmitter and indicator, together with suitable airline and connectors. The gauge is suitable for all liquids compatible with the materials of the bulb and its housing. This is normally of high-grade cast iron, which may be stove-enamelled, hot-tinned, or left in natural finish depending on the liquid being gauged. To meet varied requirements a choice of six types of installation is available. The transmitter unit, weighing 12 lb. and with an overall diameter of 8¼ in., can be mounted externally with a short pipeline entering either the side or bottom of the tank to penetrate above sludge level. When mounted internally it can be suspended from a chain in three methods of installation or alternatively be firmly clamped in the base of the tank. Three of the methods of internal installation allow the transmitter to be placed above sludge level. The maximum length of airline should only be used if the greater part of it is exposed to atmospheric temperature. The maximum recommended working temperature of the transmitter unit is

IMPROVED COOLING PERFORMANCE BY POLYGRID PACKING



Performance of Polygrid in Counterflo Cooling Tower

Polygrid—a new high-efficiency non-corrosive plastic packing has been performance-proved in more than 100 cooling tower installations. It is used exclusively in Head Wrightson Fluor Counterflo towers. Head Wrightson Processes Ltd. will also install it in established mechanical or natural draught towers of all types and makes to increase their efficiency and performance.



Polygrid is a moulded unit of two inch squares. Units, staggered in layers, break hot water into droplets as it cascades through the tower. Available in high impact polystyrene for resistance to water, acids, salts and alkalis, and in high density polyethylene for cooling water contaminated by hydrocarbons.

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P.3542

65°C (150°F). The gauge can be equipped with additional accessories to provide automatic high- or low-level alarm indications or automatic control of a pump to maintain the liquid level in the tank between predetermined limits. **Firth Cleveland Instruments Ltd., Stornoway House, Cleveland Row, London, S.W.1.**

BCE 7144 for further information

High-speed Screw Elevator

The latest development of James Hodgkinson (Salford) Ltd. is the high-speed screw elevator. It has been designed primarily for handling boilerhouse smalls where, for one reason or another, it is not convenient, or possible, to prepare a concrete ground hopper or pit. For feeding the hoppers of "low ram", chain grate or underfeed stokers under such circumstances it is ideal. The elevator consists of a steel tube in which rotates a worm housed in totally sealed, self-aligning ball bearings and driven by a constant-speed, totally-enclosed motor mounted on a platform at the head of the casing. A short standard chute extends from the head to which an additional section or breeches piece can be added, provision being made for this to be swivelled to suit site conditions. At the tail the worm is exposed for the entry of coal. An adjustable device enables the head to be supported from any convenient structure in the boilerhouse. Each unit will handle up to 1½ tons of smalls per hr and feed direct to the stoker simply by resting its tail on a pile of coal and lifting the head into position over the stoker hopper. The elevator is entirely self-cleaning and no running maintenance is required, since the bearings are grease packed and sealed for life. Costly erection expenses and delays are eliminated—the machine can be working within half an hour of delivery. The high-speed screw elevator is supplied in the following standard lengths: 13 ft, 14 ft, 15 ft, 16 ft, 17 ft and 18 ft. **James Hodgkinson (Salford) Ltd.**

BCE 7145 for further information

Cutter Mills

New models of a mill suitable for the size reduction of materials ranging from plastics, such as nylon, to asbestos pulp, have been announced by Apex Construction. In this design of mill, size reduction is obtained by pure shearing action and not by impact, the resulting product being extremely uniform in size and power consumption economically low. The cutting chamber carries rotating and stationary blades (the latter being adjustable), the number of blades varying from model to model. Normally the mills are constructed from steel or cast iron, but polished stainless-steel working parts can be supplied for applications requiring the absence of product contamination. The smallest model in the range is some 3 in. in diameter by 1¼ in. deep, while the largest machine in the range has a cutting chamber 18 in. in diameter by 55 in. long and is powered by a 50-hp motor. The machines are fitted with interlocking safety switches so that they cannot be driven when they are open. An electromagnetic brake can also be fitted to the motor driving a mill to ensure that the rotor stops when the mill door is opened. **Apex Construction Ltd., 15 Soho Square, London, W.1.**

BCE 7146 for further information

Re Apparatus

Q.V.F. Ltd. have developed an apparatus to be marketed as a pre-packaged unit in which the Reynolds Number experiment can be carried out in a quantitative way. The apparatus is supplied as a free-standing packaged unit which requires only to be connected to a main water supply and provided with a drain. Water consumption at maximum flow rate on the rotameter is 200 gal./hr. **Q.V.F. Ltd., Duke Street, Fenton, Stoke-on-Trent, Staffs.**

BCE 7147 for further information

Sealed Proximity Detector

The latest form of an earlier capacity-operated switch has a control unit sealed against the ingress of dust and moisture, together with a sensing probe, is operated by any physical variable appearing as a small movement and will detect a capacity change of 0.05 pF, representing a movement of the order of tenths of thousandths of an inch. The detector may be used for level control and counting, sorting, gauging and limit switching. The probe may be mounted directly on the case or at the end of a flexible armoured cable which may be up to 30 ft in length without loss in sensitivity; it is unaffected by heat or rough treatment. It may be fitted with a cover for use in liquids or corrosive atmospheres. **Airmec Ltd., High Wycombe, Bucks.**

BCE 7148 for further information

New Publications

"Wiggin High-nickel Alloys *v.* Sulphuric Acid" is a new publication issued by Henry Wiggin & Co. Ltd. It is the latest of a series of publications issued by the company, dealing with the corrosion-resisting properties of its high-nickel alloys. These are well known in the field of chemical and process engineering, and this publication gives highly detailed information with many photographs and tables on their particular properties. Monel, "AT" nickel, Inconel, Ni-o-nel and the Corronel alloys are particularly featured in well-proven applications. Examples of their successful uses in pickling equipment, chemical plant, food processing equipment and petrochemical plant are featured. **Henry Wiggin & Co. Ltd., Publicity Department, Millbank, London, S.W.1.**

BCE 7149 for further information

Two leaflets on "ManMil" Superfloor, said to be a hard, wear-resisting flooring with exceptional resistance to many chemicals and especially effective against attack by most inorganic acids and alkali, have recently been issued by **ManMil Plastics Ltd., Castle Street, Stalybridge, Cheshire.**

BCE 7150 for further information

"Cambridge News P15" gives details of the Cambridge Minican temperature recorder which can be used under many unusual conditions—in cooking vessels of all sizes, on lorries hauling perishable goods, in sterilising processes or in any other situation where there are a few inches available to place this pocket-size, self-contained instrument.

One of the outstanding applications of the Minican temperature recorder is in the canning and brewing industries, where the bulb may be sealed in a tin or bottle and the complete instrument passed along a conveyor belt, providing a continuous record of the process temperatures. The instrument consists of a chart (40 mm wide) mounted on a drum which revolves at a constant rate, permitting a pen to trace a temperature record for two, 12 or 24 hr. The pen is moved by the expansion and contraction of the liquid in the stainless-steel bulb, which may be either plain or spiral-shaped. The drum is operated by a built-in mechanical clock which runs for one of the three fixed periods mentioned above.

In use, both chart and pen are completely enclosed in a chromium-plated brass cylinder which is liquid and gas proof and is capable of standing up to high cooking pressures, so that the complete instrument may be enclosed in ovens or cold stores.

Accuracy of 0.5 mm (0.02 in.) on the chart width is to be expected and the minimum range is 50° across the chart, e.g., 120/170°F or 240/290°F; −30/+20°C or 110/160°C. Further details from **Cambridge Instrument Co. Ltd., 13 Grosvenor Place, London, S.W.1.**

BCE 7151 for further information

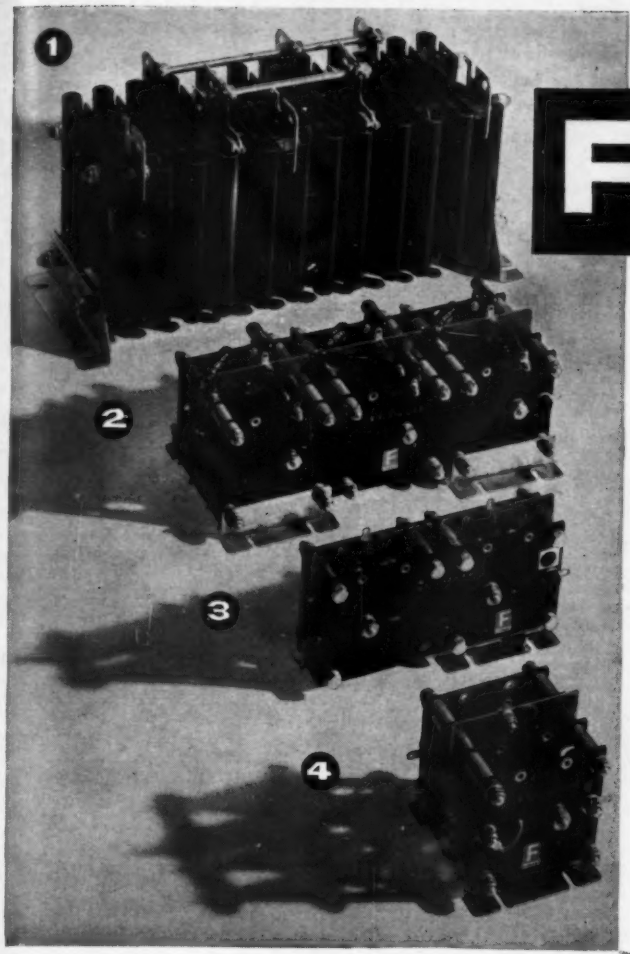
Rockweld Ltd. have produced a new brochure, "Comet", which describes their recently-introduced Comet process—semi-automatic welding with CO_2 shielding. In the Rockweld Comet process the arc is struck between a special composite continuous wire and the workpiece in an atmosphere of carbon dioxide gas. The wire contains the deoxidising agents and the slag-forming materials, whilst the carbon dioxide protects the metal from atmospheric contamination during transfer and in the weld pool. It is readily adaptable for both automatic and semi-automatic operation. **Rockweld Ltd., Commerce Way, Croydon, Surrey.**

BCE 7152 for further information

A statement by Lord Boyd-Orr, D.S.O., M.C., F.R.S., LL.D., Commander of the Legion of Honour and a list of guests at a recent reception are given in a new brochure entitled "A Chance to Raise Exports £100 Million A Year". It also includes tables of United Kingdom exports to planned-economy countries, 1949-59, including figures for iron and steel, and non-ferrous metals. **British Council for the Promotion of International Trade, Hanover Square, London, W.1.**

BCE 7153 for further information

BCE 7082 for further information



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silicon High Power Rectifier Stacks

1. 3 phase type
   Ratings up to 84/168 amps and 300/150 volts DC
   Size 13¼" x 6½" x 4¾"
2. 3 phase type
   Ratings up to 22/44 amps and 300/150 volts DC
   Size 8⅝" x 4½" x 3½"
3. 1 phase type
   Ratings up to 16 amps and 200 volts DC
   Size 5¾" x 2" x 3 7/16"
4. 1 phase type
   Ratings up to 16 amps and 200 volts DC
   Size 2¾" x 3½" x 3½"

Special Features

- Reliability at high temperature.
- High power to space ratio.
- Very high rectification efficiency.

APPLICATIONS

Ferranti high power silicon rectifiers have many applications in the aircraft, electronic, electrical, chemical, marine and general engineering industries including aircraft and marine power supplies, radar systems, computers, chemical processing, welding and electroplating.

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FE 196a

World of Chemical Engineering

I.C.I. Developments

Rapid progress on the erection of I.C.I.'s polypropylene (Propathene) plant at Wilton, Yorkshire, has been reported. This 10,000-ton-capacity plant should be on stream towards the end of 1960, instead of 1961 as was previously expected. The site is now fully developed and roads and buildings have been completed ready for the processing equipment to be installed. I.C.I. believe that the Propathene plant will be the first commercial-scale polypropylene plant to come into operation in this country and it is being so built that it will allow for rapid expansion.

The I.C.I. (Plastics Division) plant for Propathene at Wilton in course of erection.

Alongside the Propathene plant, I.C.I.'s Plastics Division will produce organo-aluminium compounds in bulk for use as catalysts in the process. Development of this project is also stated to be making excellent progress. Plastics Division have also announced that they are to increase polythene production by approximately 15% in 1960, bringing the annual output to about 105,000 tons. The supply position will be further improved by redeployment of total sales. As a result of the completion of new I.C.I. plants in India and Australia, and increased production in France and Germany, more polythene will be available for home distribution.

Developments in international relations between I.C.I. and Eastern Europe are growing, as is shown by the conclusion of an agreement between I.C.I. and the Czechoslovakian Silon National Corp., whereby I.C.I. has granted to the Corporation a non-exclusive licence under certain patents in Czechoslovakia for the manufacture of polyester fibre. The rights granted do not cover the provision of technical information or any rights to use I.C.I.'s trade-mark 'Terylene'. The agreement involves the payment to I.C.I. during the first half of this year of some £220,000. Further news of growing East-West trade is given by the announcement that I.C.I. have been granted two patents recently in Rumania for the manufacture of biguanidine derivatives.

Albright Joins with Boake

An announcement of an agreement to merge Albright & Wilson Ltd. and A. Boake, Roberts & Co. (Holding) Ltd. has been issued by the boards of both companies. The merger will be effected by an offer of Albright & Wilson shares on the basis of one Ordinary stock unit of 5s. of Albright & Wilson plus 2s. in cash for each Ordinary 5s. stock unit of Boake, Roberts and one 5% Cumulative Preference stock unit of £1 of Albright & Wilson plus 1s. in cash for each 5% Cumulative £1 Preference share of Boake, Roberts. The boards of both companies have announced details of dividends they propose to declare should the merger be completed.

Overseas News

Marchon Products Ltd., a member of the international Albright & Wilson group of companies, are proceeding with plans for the manufacture of detergent raw materials in Northern Italy by their wholly-owned subsidiary, Marchon Italiana. The factory site is at Castiglione delle Stiviere, approximately 80 miles east of Milan, and the plant is scheduled to be completed by the end of the year.

Stone & Webster Engineering Corp., Boston, state that the latest developments in the design of petrochemical plants will be incorporated in the ethylene plant being designed for SINCAT S.p.A. in Sicily. The plant is scheduled to come into operation this spring. Design and assistance in procurement and construction of the plant is being carried out by Stone & Webster Engineering Ltd., London, the company's British affiliate. Since 1946 the Stone & Webster group has built more than 20 ethylene plants (stated to be more than any other engineering and construction organisation in the world) in America, Japan, Great Britain, France and other countries.

The foundation stone of an £18-million refinery at Mersin, in South-east Turkey, was laid by Mr. A. Manderes, the Prime Minister of Turkey, on January 6. The project is being financed by three refining companies associated with Mobil International, Royal Dutch/Shell and British Petroleum, whose shares in it will be 56%, 27% and 17% respectively. The new refinery will have a capacity of 65,000 barrels a day and is expected to go on stream towards the end of 1961. Foster Wheeler Ltd., London, an affiliate of the Foster Wheeler Corp. of America, will build the Mersin refinery.

Power Gas Corp. (Australia) Pty. Ltd. has received an order from Sulphide Corp. Pty. Ltd. for the supply and erection of the charge handling plant for a new smelter being erected at Cockle Creek, near Newcastle, N.S.W. The value of the order is about £A.3,000,000 and the installation is to be completed by the end of 1960. The new smelter is an improved vertical furnace-type and will utilise the blast-furnace principle to produce zinc and lead metal simultaneously.

Glaxo have opened a new plant in Malaya. Costing $M.2 million, the new plant will employ 80 workers and will manufacture special foodstuffs, antibiotics and pharmaceuticals; the range of products, it is planned, will be increased gradually.

Blaw Knox Chemical Engineering Co. Ltd. has been awarded a contract by National Adhesives Ltd. for an additional polyvinyl acetate emulsion plant to be erected at National Adhesives factory at Slough. The plant is scheduled for completion in mid-1960. This new plant will enable an increase in production of standard polymers, complex polymers and internally plasticised copolymers by National Adhesive.

Humphries & Glasgow Ltd., in association with its Japanese licensees, has won a contract to install an oil gasification plant in Osaka, which, it is claimed, will eventually be the largest in the world. The initial cost will be around £700,000 for a plant making 20 million cu. ft of town gas a day.

News Briefs

The agreement to acquire a 53.125% interest in the Solartron Electronic Group Ltd. by Firth Cleveland Ltd. will immediately provide £900,000 to ensure the adequate financing of Solartron's next five-year period of development and expansion. Mr. C. W. Hayward, the chairman, and Mr. G. Harries, secretary of Firth Cleveland, will join the Solartron board. Mr. J. E. Bolton will be deputy chairman and managing director.

Chemical Construction (G.B.) Ltd. and Whessoe Ltd. announce that they are to collaborate in the future design and construction of Chemico catalytic carbon monoxide removal plants for the detoxification of town gas.

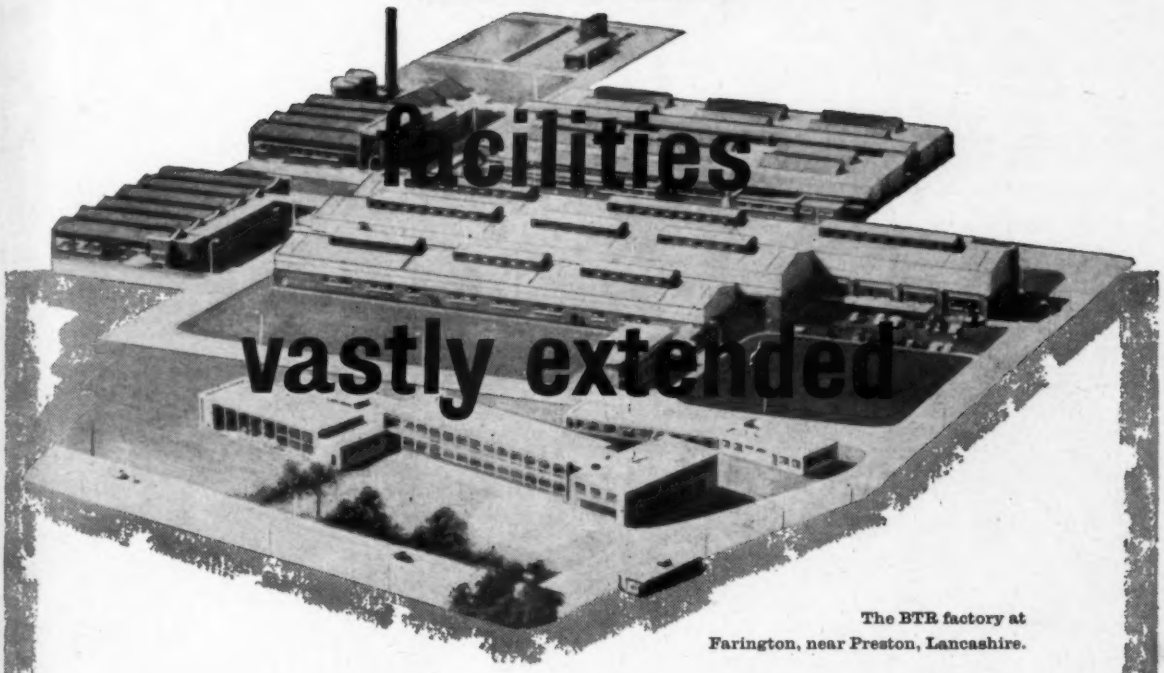
An agreement has been concluded between Kelvin & Hughes Ltd. and the Curtiss-Wright Corp. of America for the exclusive right to manufacture and sell the non-destructive testing equipment of the other. This includes instruments for the inspection and measurement of materials and equipment employing ultrasonic techniques in all industrial fields. Kelvin & Hughes will represent both interests in the U.K., the Commonwealth (except Canada) and Europe, and Curtiss in the U.S.A. and Northern America. Each party will offer full sales and service facilities on the joint range of equipment.

At the recent luncheon of the British Industrial Measuring and Control Apparatus Manufacturers' Association, it was stated by Mr. V. D. MacLachlan, chairman of the Association, that since 1944 the industry's annual turnover had grown from £3 million to £35 million.

BCE 7083 for further information

rubber linings

BTR



The BTR factory at
Farington, near Preston, Lancashire.

Here, in a new factory at Farington specially designed and equipped to provide speedy and efficient customer service, are now housed the very considerable resources of the BTR Linings and Coverings Department. With production plant and facilities of the most modern kind backed by an accumulation of specialised knowledge and technical experience unrivalled in the business, BTR offers a design and manufacturing SERVICE as wide in its scope as it is efficient in operation. For all rubber lining and covering requirements—anti-corrosion, anti-abrasion—consult BTR.

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BRITISH THERMOPLASTICS & RUBBER MANUFACTURERS

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4/3038

W. J. Brooker Ltd., London, industrial painting contractors, announce the formation of an associated company, Brook-Blast Ltd. This new company will specialise in on-site shot blasting, metal spraying and protective coating operations in all parts of the country. Mr. W. J. Brooker and Mr. D. M. Legget are appointed directors.

Contracts

An agreement involving the construction of new and expanded plant for the manufacture of petroleum chemicals in New South Wales has been reached between Shell Chemical (Australia) Pty. Ltd. and Imperial Chemical Industries of Australia and New Zealand Ltd. Shell Chemical will erect an ethylene manufacturing and purification unit at Clyde, N.S.W., while ICIANZ's plant at Botany, already extended several times, is currently being further increased, and the total investment represented by ICIANZ's extended facilities at Botany and Shell's new ethylene plant at Clyde will be over £A10 million.

The Development Loan Fund has announced the signing of a loan agreement whereby the United States will lend $5,600,000 to the Oriental Chemical Industry Co. Ltd., a private Korean firm, to assist the establishment of a soda-ash plant and related plants at Samchok, Korea. The new plants will produce annually an estimated 39,000 metric tons of soda ash, 4200 tons of caustic soda, 2500 tons of sodium bicarbonate and 5000 tons of calcium chloride. At present Korea must import its total supply of these products.

George Wimpey & Co., of London, it has been reported, has won a contract in association with Bechtel, of San Francisco and McDonald Constructions, of Australia, to build a £A3-million styrene plant at the Melbourne suburb of Altona for C.S.R.C.-Dow Proprietary.

The plant should be completed by May, 1961.

Industrial Films

Applications in chemical engineering are among those shown in the main sequence of a new film, "Lead—The Enduring Metal", which was recently shown in London for the first time. It is intended to interest non-technical audiences. After briefly tracing history and ancient usage, there is a description of the metal's occurrence in the world today and how it is mined, smelted and refined. Shots of various uses demonstrate the versatile role played by lead in the modern world and its well-known ability to resist corrosion "Lead — The Enduring Metal" 16 mm; 28 min.; sound, colour; free. Lead Development Association 18 Adam Street, London, W.C.2.

Naturally-occurring methane can either be burnt in flares at oilfields or liquefied, transported and stored for productive use. If it is to be stored, then there is no way better than in the tanks fabricated in aluminium by G. Whessoe & Co. This is roughly the theme of a film made by the British Aluminium Co. Ltd. Switching to and fro between live shots and animated diagrams, the film refers to the crystal structure of metals, demonstrates the advantages of aluminium for use at low temperatures, then gives details of how the famous first tank at Canvey Island was built to receive the first load of liquid methane.

Commentary accompanying early live shots is at times a bit gabbled. Even at this stage some modification of the sound track of this part might be an advantage. The animated diagrams and their commentary, however, are lucid-clear and the film is well worth seeing for these alone—particularly the sequences tracing the stages of the construction and showing essential features of the resultant structure.

Target audiences for this presentation are chemical and other engineers and metallurgists. The film runs for 22 minutes and is available free on loan from the makers. "Aluminium for Methane Storage Tank Construction." 16 mm. Sound. Colour.

Timber used in wet conditions is very liable to biological attack. The protection offered by the use of Tanalith C preservative is dramatically shown in a new film, "Timber Exposed", produced by Hickson's Timber Impregnation Co. by frequent comparisons of treated and untreated samples which have been exposed to a range of conditions. Examples include the case of exposure in cooling towers. Carefully controlled vacuum-pressure impregnation practice for applying the material is also briefly demonstrated.

To establish the fact that the preservative cannot be washed out of timber, there are several laboratory scenes showing Soxhlet extraction; others follow mycological studies on test samples to examine loss of weight and strength. Film in sound, colour, 16 mm, runs for 23 min., free.

People in the News

Professor K. G. Denbigh Professor of Chemical Technology at Edinburgh University, has been appointed to the university chair of chemical engineering science tenable at the Imperial College of Science and Technology from October 1, 1960.

Mr. C. R. Evans has joined Servomex Controls Ltd., Crowborough, as manager of the Chemical Instruments Division. Mr. Evans is at present supervising several new development projects in the chemical instrumentation field as well as the magnetic oxygen analyser being made by Servomex under licence from the Distillers Co. Ltd.

Dr. J. McAfee, vice-president, Manufacturing Department, Gulf Oil Co., Pittsburgh, has been elected 1960 president of the American Institute of Chemical Engineers (A.I.Ch.E.) it was announced during the recently held 52nd annual meeting of the Institute **J. J. Healy, Jr.**, a member of the Corporate Planning Group of Monsanto Chemical Co., St. Louis, was elected vice-president.

The Wellcome Foundation Ltd. announce that they have appointed **R. C. de B. Devereux** as chief engineer to the Foundation. Mr. Devereux was educated at Repton School and at Emmanuel College, Cambridge, from which he graduated B.A. in 1952 with Honours in the Mechanical Sciences Tripos, Part I, and the Law Tripos, Part II. In the same year he joined Heinz Ltd. and in 1953 transferred to the Wellcome Foundation Ltd. as engineer to the Pharmaceutical Division at Dartford. He became an M.A. in 1955, and in 1958 was appointed assistant engineer. Mr. Devereux is a member of the Institute of Mechanical Engineers.

Foster Wheeler Ltd. announce the following changes to the board of directors, which became effective on January 1, 1960. **Mr. C. E. H. Verity,** to managing director, but will continue as manager, Steam Division. **Mr. R. B. Kerr,** to deputy managing director, and manager, Process Plants Division. **Mr. Hopewell**, who resigned from the managing directorship, will remain a director of the company, and takes up the position of deputy chairman. **Mr. H. T. Collinswood** retired from the post of manager, Process Plants Division, but remains a director of the company.

Mr. P. Colebrook, managing director of Pfizer Ltd., has been appointed managing director of Kemball, Bishop & Co. Ltd., fine chemical manufacturers. He succeeds **Mr. W. W. Muir** and **Mr. R. F. Kemball,** joint managing directors. Mr. Muir is remaining on the board in an advisory capacity.

Dr. C. G. Williams, director and general manager of Shell Research Ltd., has been nominated by the Council of the Institution of Mechanical Engineers as a member of the Board of Studies in Engineering of the National Council for Technological Awards.

Mr. A. T. Rogers, technical director and chief engineer, and **Mr. R. F. Jennings**, technical director, have been appointed directors of Huntington, Heberlein & Co. Ltd. (a subsidiary of Simon-Carves Ltd.).

Obituary

We regret to announce the death of **W. J. Murphy**, editorial director of the American Chemical Society's Applied Journals, who died on Thursday, November 26, at Georgetown University Hospital, Washington, D.C.

Dr. Murphy's death came at the height of an active career devoted to the American chemical profession and industry. Under his leadership during the past 17 years the A.C.S.-Applied publications become the largest scientific publications programme in the world, with a total circulation of over 165,000.

Dr. Murphy was also director of the Society's News Service and was largely responsible for its evolution from a part-time office into a well-rounded public relations organisation which has heightened public appreciation of the role of the chemist and the chemical engineer in modern civilisation.